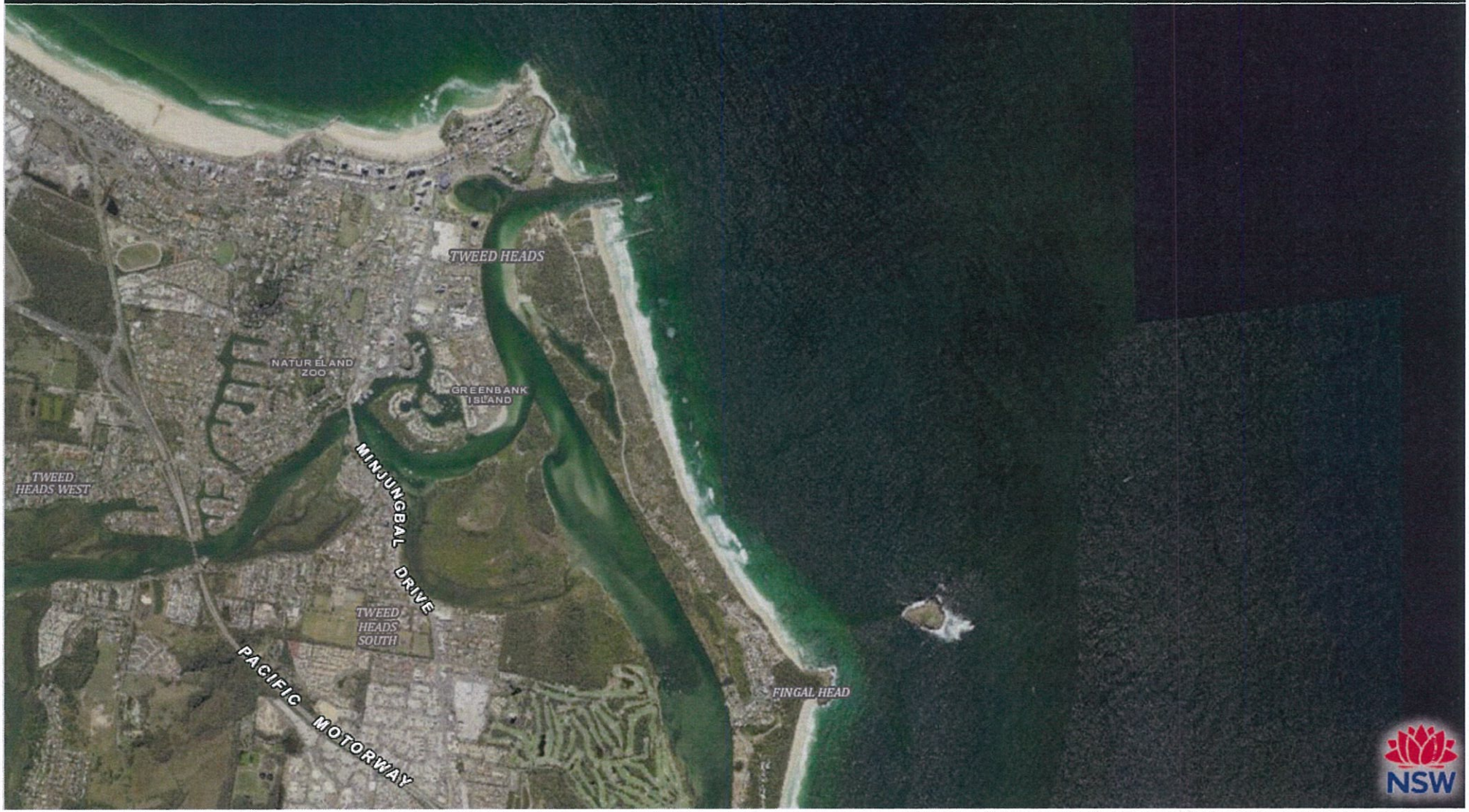
Appendix A
Photographs of project works area

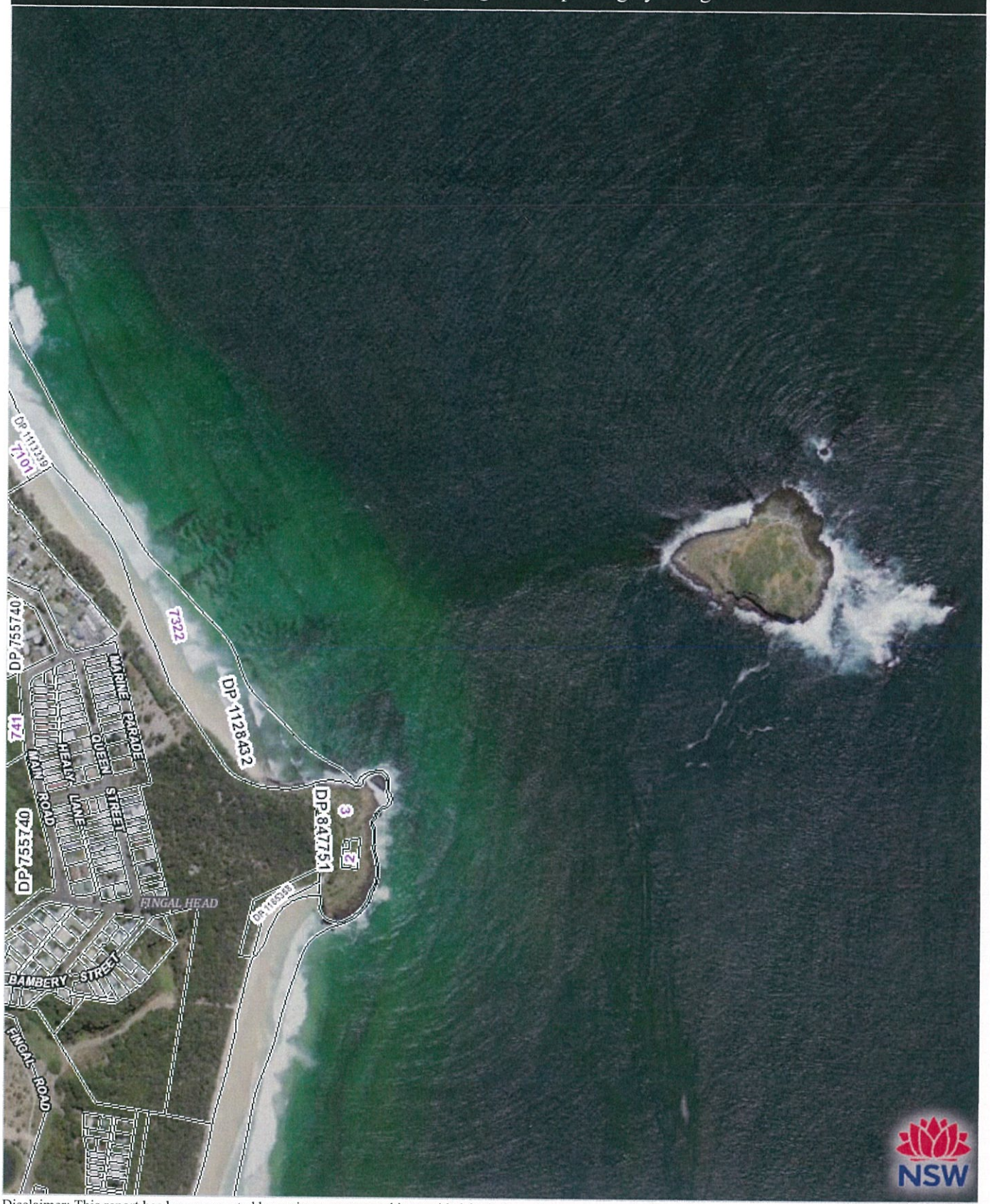
Tweed Sand Bypassing - Back-passing by dredge

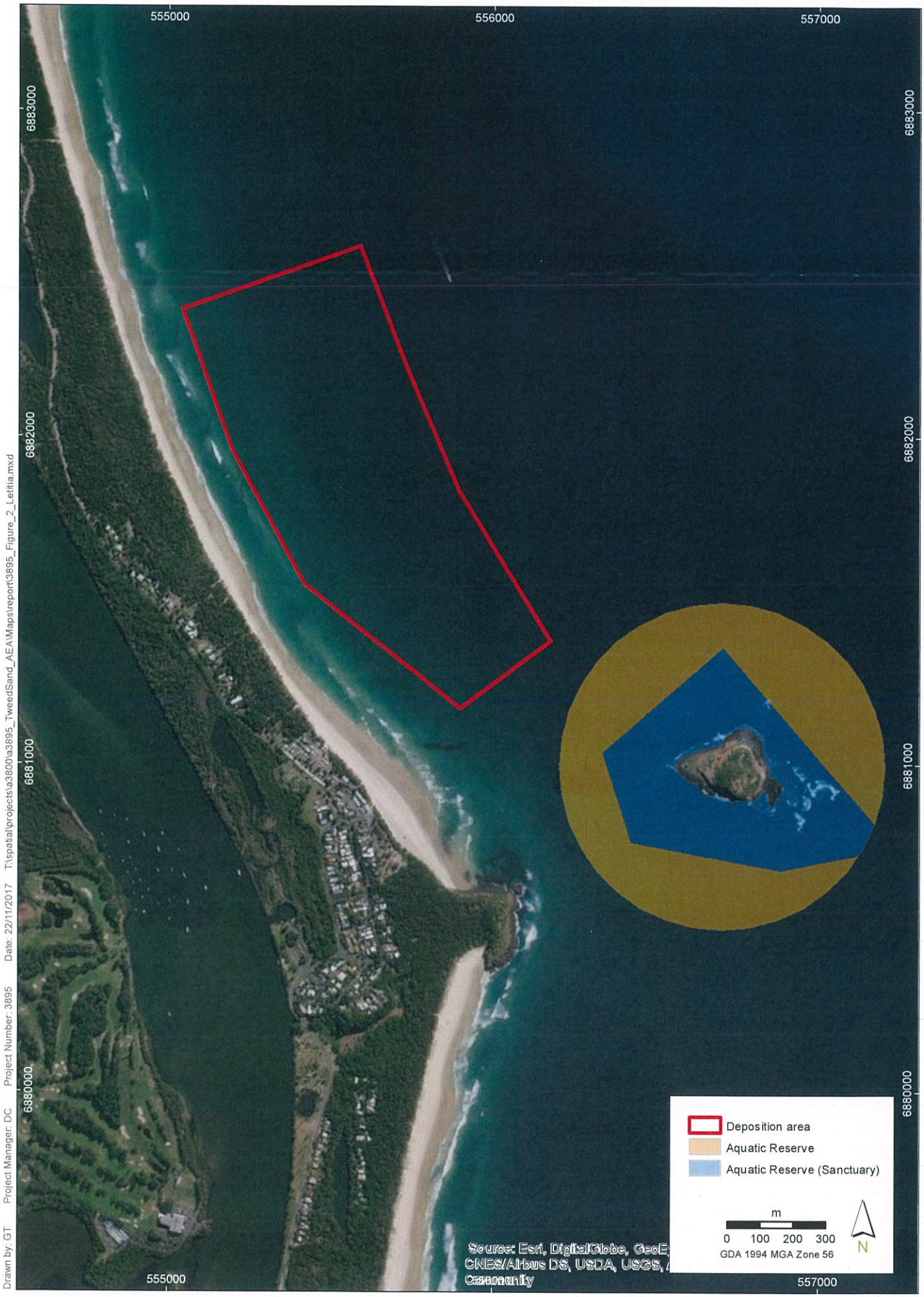
Locality Plan



Locality Plan

Tweed Sand Bypassing - Back-passing by dredge





Drawn by: GT Project Manager: DC Project Number: 3895 Date: 22/11/2017 T:\spatial\projects\a3800\a3895_TweedSand_AEAIMaps\report\3895_Figure_2_Letitia.mxd

Letitia sand backpass area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

FIGURE 2

Imagery: (c) DigitalGlobe 2016-01-06

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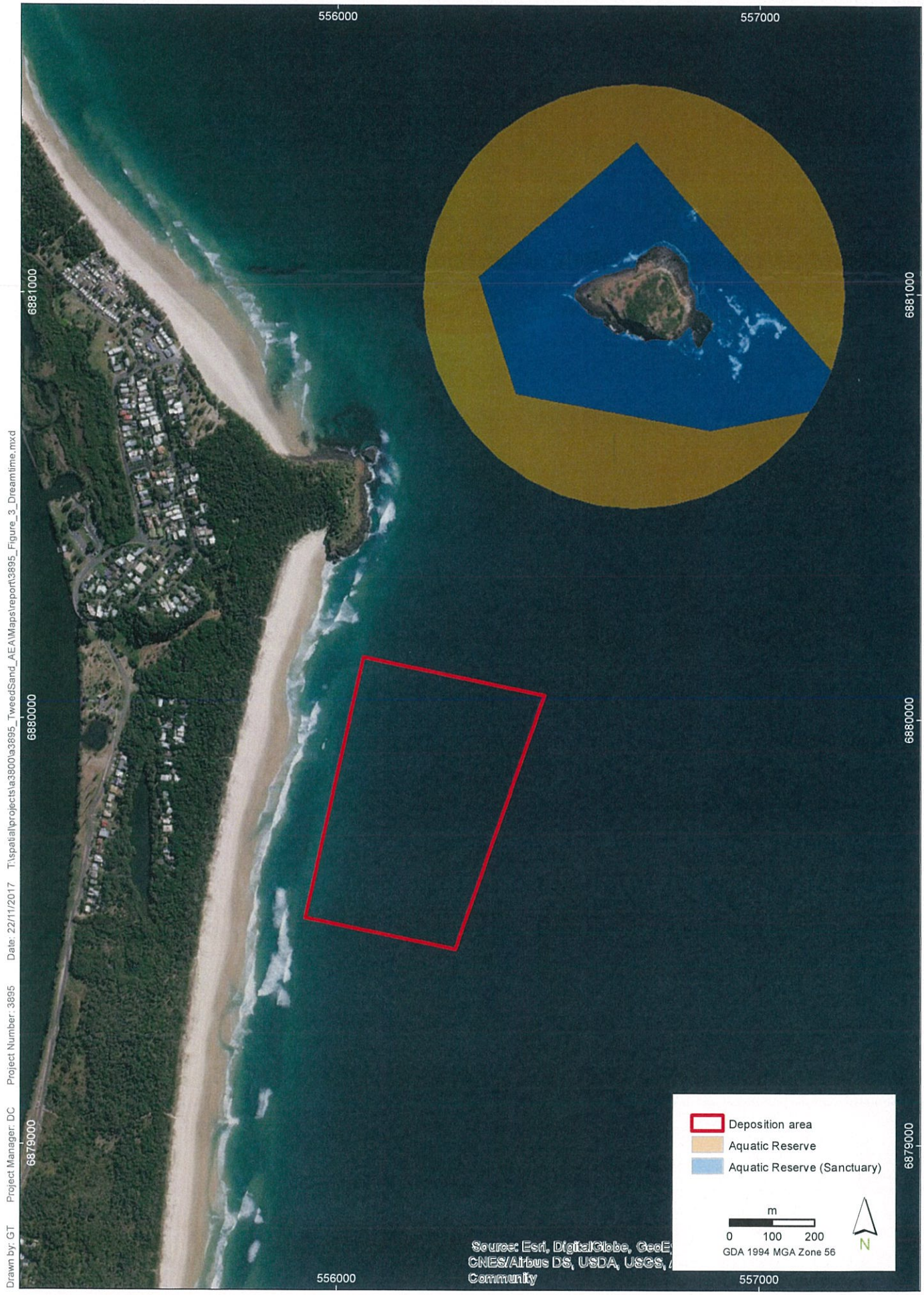

Dreamtime sand backpass area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

FIGURE 3

Imagery: (c) DigitalGlobe 2016-01-06

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TWEEDSAND BYPASSING

Oblique Aerial Photos of Tweed Sand Bypassing Project Area

7 June 2017

Fingal Head & Letitia

Figure 1 – Fingal Head looking North (13155-01)

Figure 2 – Letitia Spit looking South (13156-21)

North Letitia, Tweed River Entrance and Duranbah

Figure 3 – North Letitia, Tweed River Entrance and Duranbah looking West (13156-41)

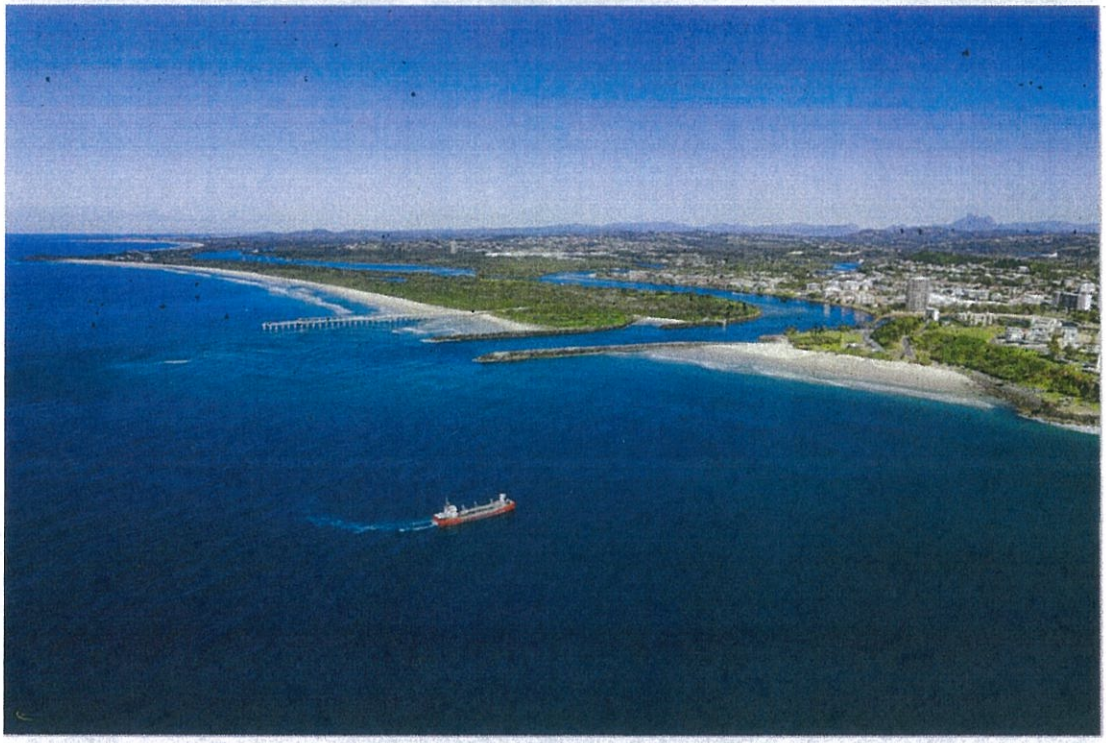


Figure 4 –Duranbah and Dredger looking Southwest (13156-44)

Southern Gold Coast Beaches

Figure 5 –Snapper Rocks looking South (13157-10)

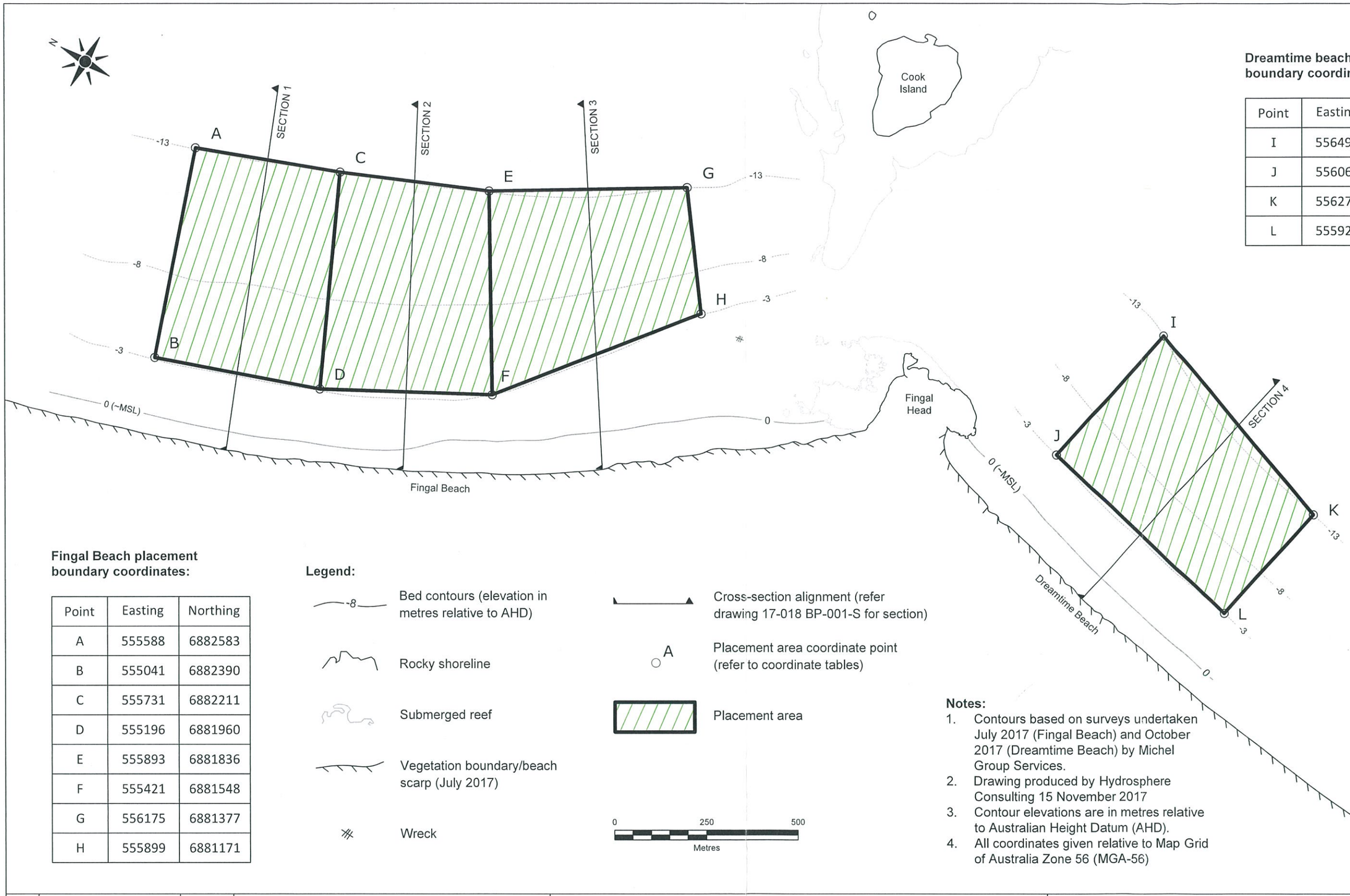
Figure 6 –Snapper Rocks to Kirra (13157-07)

Figure 7 –Kirra looking South (13157-50)

Currumbin

Figure 8 –Currumbin looking South (13158-25)

Appendix B
Plans of proposed deposition areas



Dreamtime beach placement boundary coordinates:

Point	Easting	Northing
I	556490	6880055
J	556062	6880144
K	556279	6879459
L	555926	6879532

Fingal Beach placement boundary coordinates:

Point	Easting	Northing
A	555588	6882583
B	555041	6882390
C	555731	6882211
D	555196	6881960
E	555893	6881836
F	555421	6881548
G	556175	6881377
H	555899	6881171

Legend:

- -8 — Bed contours (elevation in metres relative to AHD)
- Rocky shoreline
- Submerged reef
- Vegetation boundary/beach scarp (July 2017)
- Wreck
- Cross-section alignment (refer drawing 17-018 BP-001-S for section)
- A — Placement area coordinate point (refer to coordinate tables)
- Placement area

0 250 500
Metres

Notes:

1. Contours based on surveys undertaken July 2017 (Fingal Beach) and October 2017 (Dreamtime Beach) by Michel Group Services.
2. Drawing produced by Hydrosphere Consulting 15 November 2017
3. Contour elevations are in metres relative to Australian Height Datum (AHD).
4. All coordinates given relative to Map Grid of Australia Zone 56 (MGA-56)

Mk	Details of Amendment	Approved

QUEENSLAND GOVERNMENT

NSW GOVERNMENT Department of Industry

DEPARTMENT OF INDUSTRY - LANDS & FORESTRY

DEPARTMENT OF SCIENCE, INFORMATION TECHNOLOGY, INNOVATION (QLD)

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT

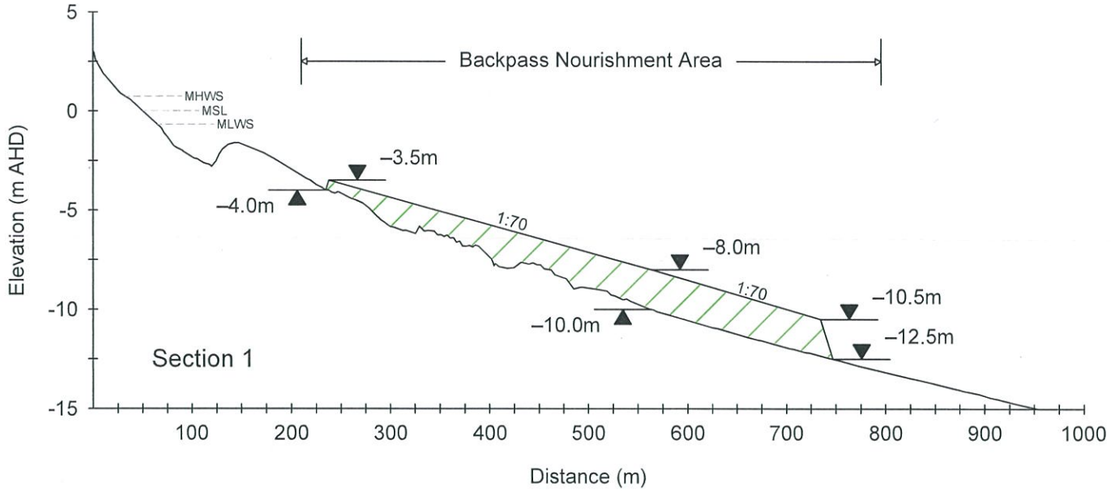
TWEED RIVER ENTRANCE SAND BYPASSING PROJECT
CONCESSION AGREEMENT

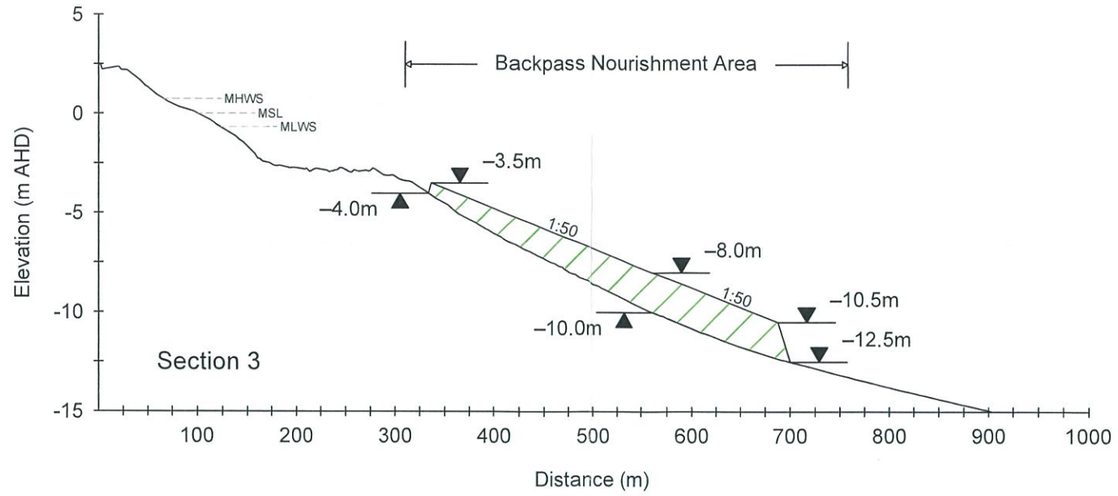
BACKPASS PLACEMENT AREAS
FINGAL AND DREAMTIME BEACHES

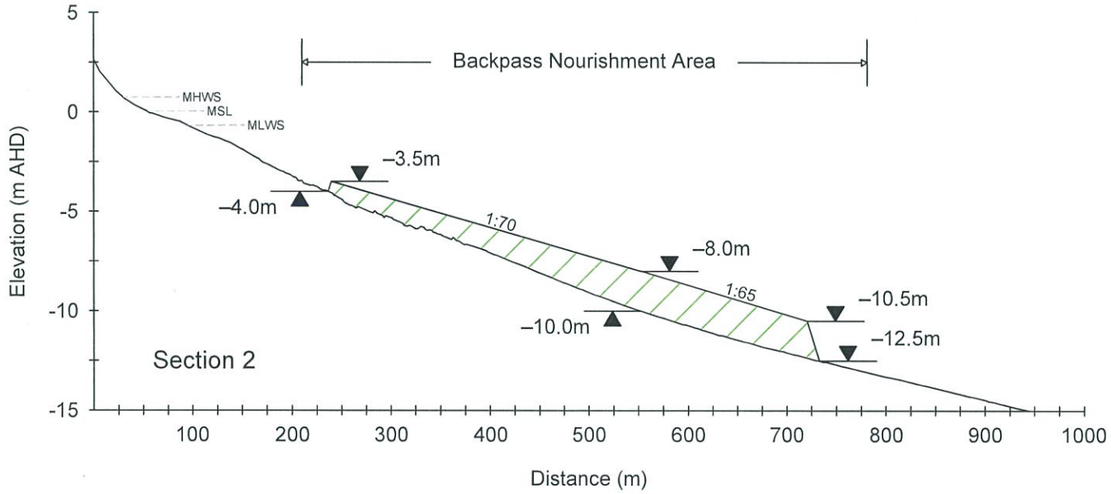
Drawing No: 17-018 BP-001-P

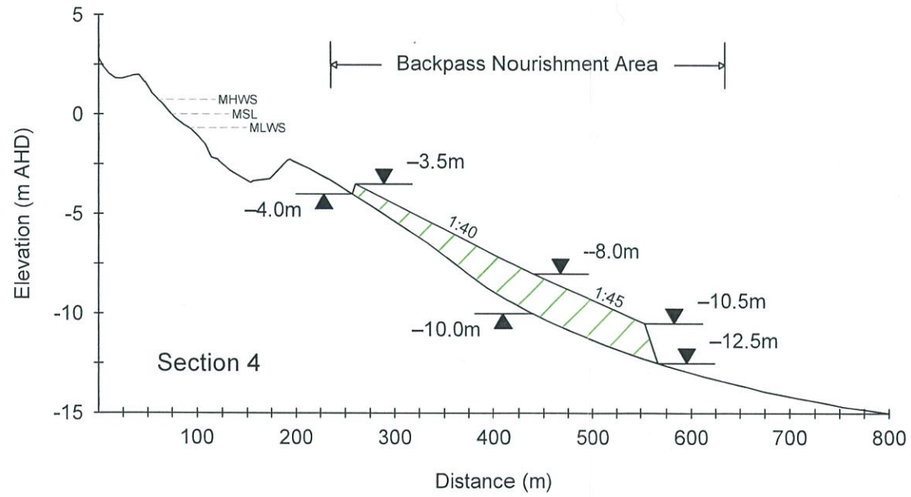
Amendment: Rev 1

Cad File No: T:\DRAWINGS\BACKPASS\LS + DT BACKPASS PLAN FOR REF.DWG









Notes:

1. Existing cross-section profile based on surveys by Michel Group Services July 2017 (Sections 1 - 3) and October 2017 (Section 4).
2. Drawing produced by Hydrosphere Consulting 12 November 2017.
3. Refer to drawing 17-018 BP-001-P for section locations.
4. All elevations relative to Australian Height Datum (AHD).
5. Inshore and offshore batters are at angle of repose (nominally 1 in 5).
6. Other profile slopes are indicative (rounded) and will vary according to existing conditions.
7. All sections have a vertical exaggeration of 20.

Tidal Information:

1. Tidal levels are based on harmonic analysis of offshore site (558309, 6882591) between 1983 and 2009 by MHL 2012.
2. Significant variations in water levels will occur due to climatic and oceanic conditions and will vary with position on coastline.

+0.688	MHWS
0.000	MSL (AHD)
-0.688	MLWS

Legend:

Design fill profile

Mk	Details of Amendment	Approved

QUEENSLAND GOVERNMENT

NSW GOVERNMENT Department of Industry

DEPARTMENT OF INDUSTRY - LANDS & FORESTRY

DEPARTMENT OF SCIENCE, INFORMATION TECHNOLOGY, INNOVATION (QLD)

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT
CONCESSION AGREEMENT

BACKPASS PLACEMENT AREAS
SECTIONS 1 - 4

Drawing No: 17-018 BP-001-S

Amendment: Rev 3

Cad File No: T:\DRAWINGS\BACKPASS\BACKPASS DESIGN PROFILES REV3.DWG

T:\Drawings\Backpass\Backpass Design Profiles rev3.dwg

Appendix C
Zoning maps (Tweed LEP 2000 and 2014)

Tweed Local Environmental Plan 2014

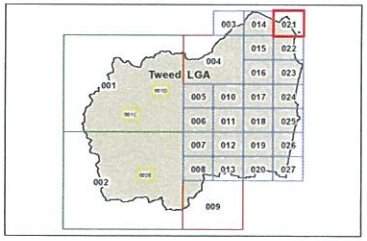
Land Zoning Map - Sheet LZN_021

Zone

- B1 Neighbourhood Centre
- B2 Local Centre
- B3 Commercial Core
- B4 Mixed Use
- B5 Business Development
- B7 Business Park
- E1 National Parks and Nature Reserves
- IN1 General Industrial
- IN4 Working Waterfront
- R1 General Residential
- R2 Low Density Residential
- R3 Medium Density Residential
- R5 Large Lot Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU1 Primary Production
- RU2 Rural Landscape
- RU5 Village
- SP1 Special Activities
- SP2 Infrastructure
- SP3 Tourist
- W1 Natural Waterways Natural Waterways
- W2 Recreational Waterways
- W3 Working Waterways
- DM Deferred Matter
- MD Major Development
- TCC Tweed City Centre

Cadastre

Base Data 13/10/2015 © Land and Property Information
Addendum Data 13/10/2015 © Tweed Shire Council



N

0 150 300 450 600 Meters

Scale : 1:20,000 @ A3

Projection: GDA 1994
MGA Zone 56

Map identification number: 7550_COM_LZN_021_020_20151013

Tweed Local Environmental Plan 2014

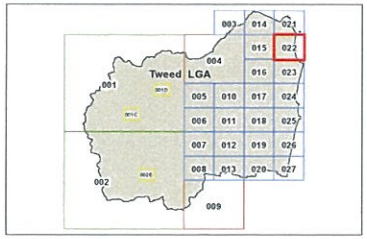
Land Zoning Map - Sheet LZN_022

Zone

- B1 Neighbourhood Centre
- B2 Local Centre
- B3 Commercial Core
- B4 Mixed Use
- B5 Business Development
- B7 Business Park
- E1 National Parks and Nature Reserves
- IN1 General Industrial
- IN4 Working Waterfront
- R1 General Residential
- R2 Low Density Residential
- R3 Medium Density Residential
- R5 Large Lot Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU1 Primary Production
- RU2 Rural Landscape
- RU5 Village
- SP1 Special Activities
- SP2 Infrastructure
- SP3 Tourist
- W1 Natural Waterways Natural Waterways
- W2 Recreational Waterways
- W3 Working Waterways
- DM Deferred Matter
- MD Major Development
- TCC Tweed City Centre

Cadastre

Base Data 03/12/2015 © Land and Property Information
Addendum Data 03/12/2015 © Tweed Shire Council



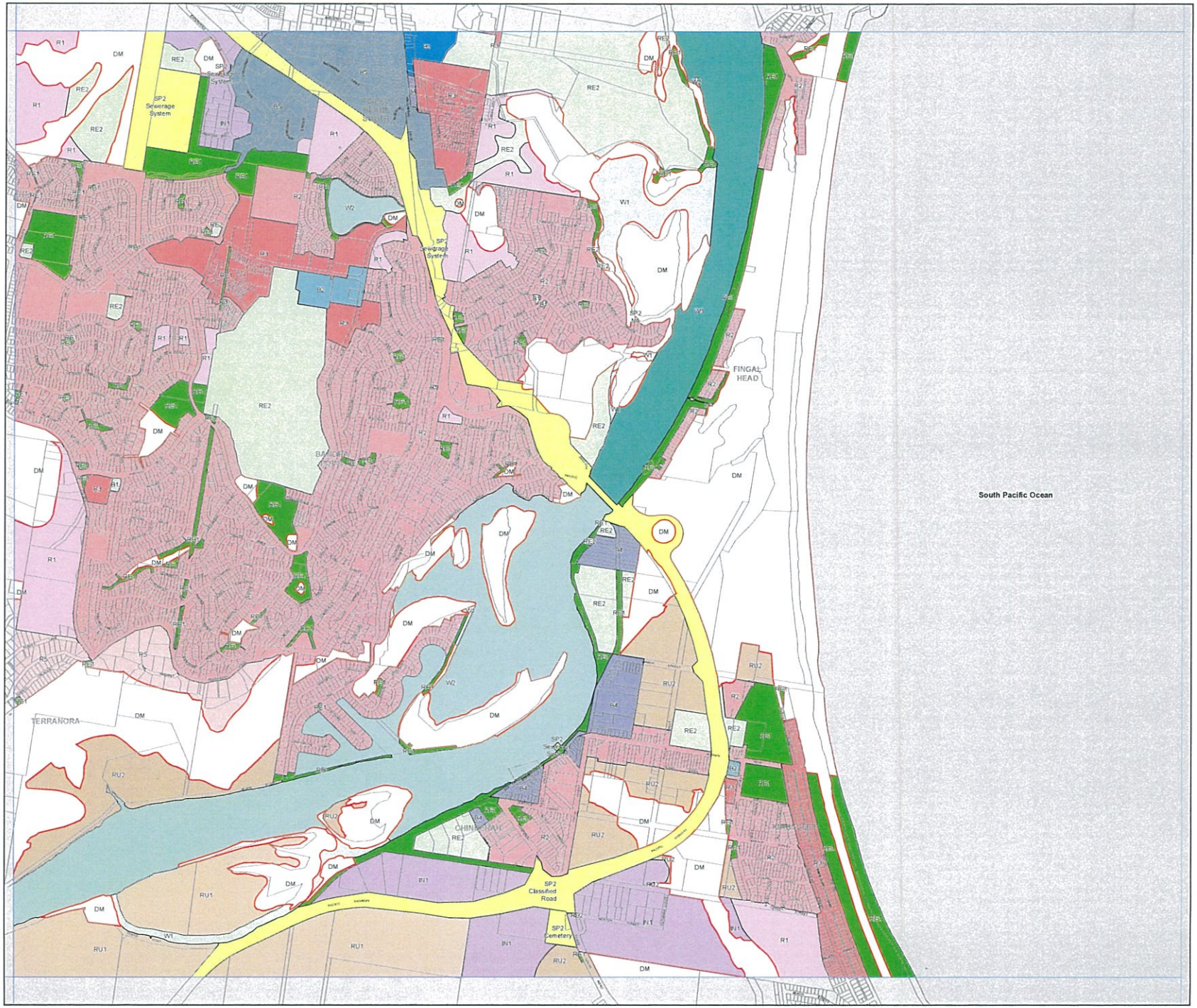
N

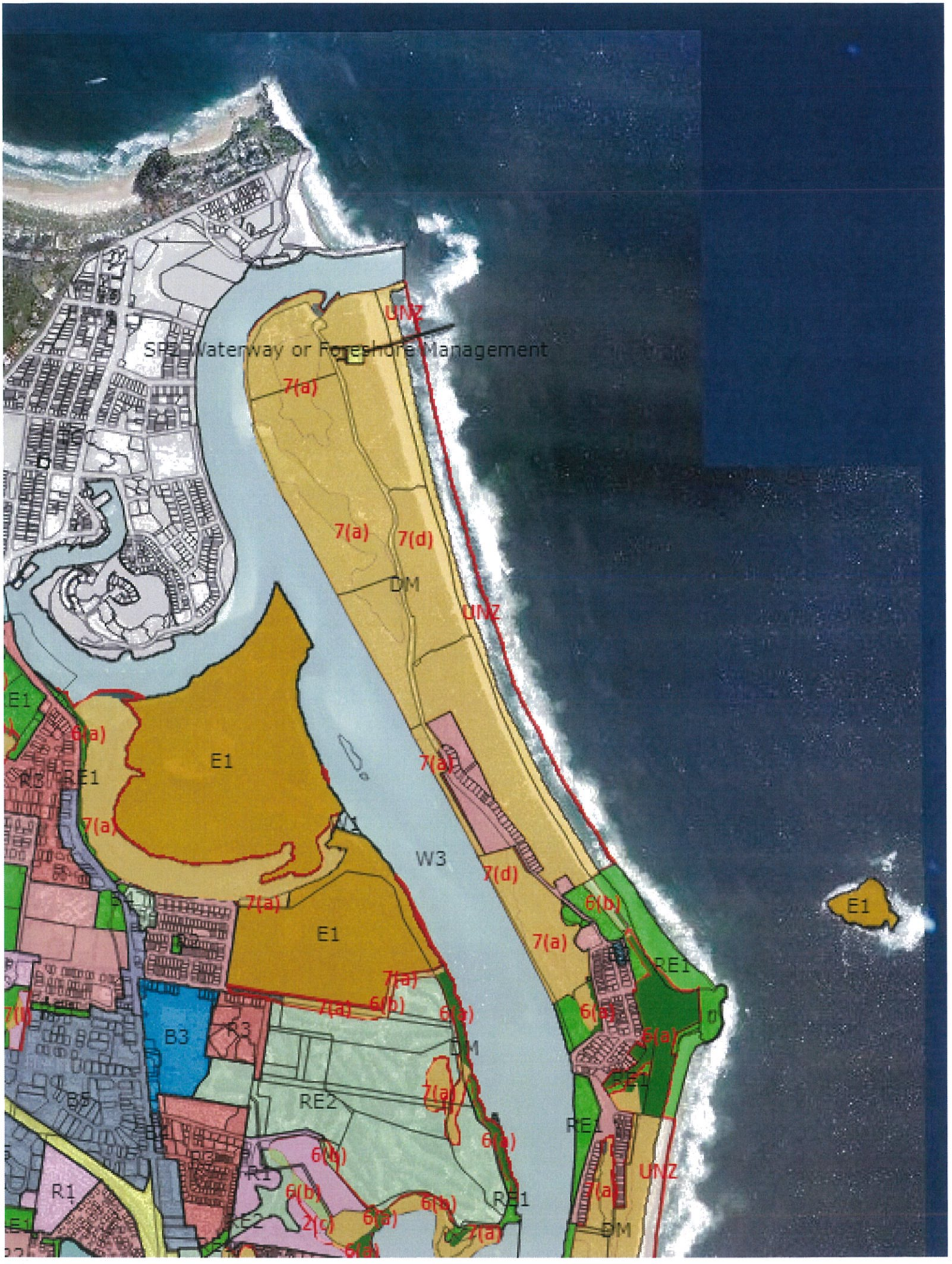
0 150 300 450 600 Meters

Scale : 1:20,000 @ A3

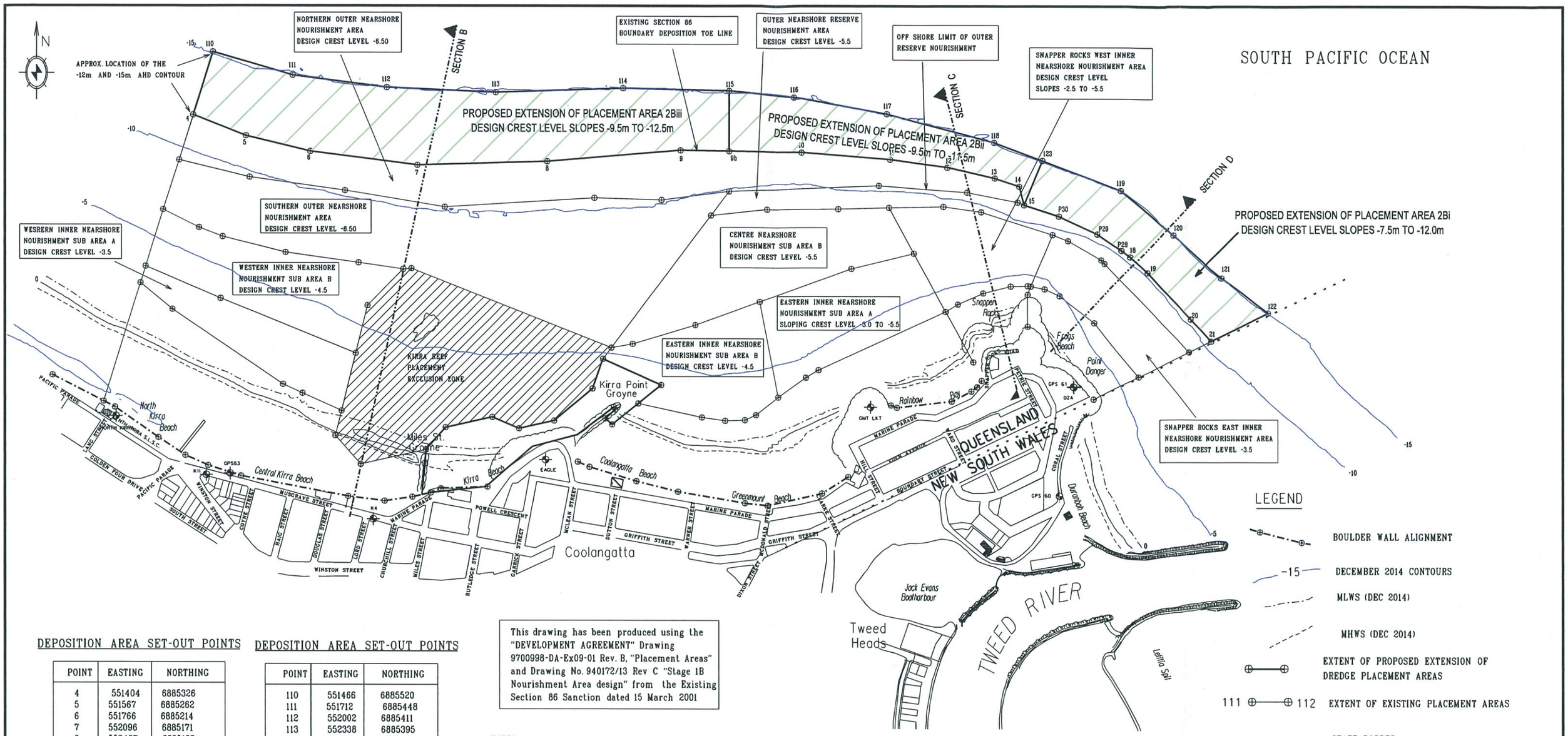
Projection: GDA 1994
MGA Zone 56

Map identification number: 7550_COM_LZN_022_020_20151203




SP2 Waterway or Foreshore Management
UNZ
7(a)
7(d)
DM
E1
6(a)
RE1
W3
6(b)
B3
R3
RE2
B5
R1
6(c)

Appendix D
Plans of proposed QLD waters placement areas



DEPOSITION AREA SET-OUT POINTS

POINT	EASTING	NORTHING
4	551404	6885326
5	551567	6885262
6	551766	6885214
7	552096	6885171
8	552497	6885183
9	552909	6885217
9b	553059	6885215
10	553282	6885211
11	553556	6885189
12	553732	6885165
13	553879	6885132
14	553954	6885107
15	553969	6885050
18	554296	6884890
19	554348	6884842
20	554483	6884699
21	554549	6884632
P28	554270	6884910
P29	554195	6884960
P30	554077	6885015

DEPOSITION AREA SET-OUT POINTS

POINT	EASTING	NORTHING
110	551466	6885520
111	551712	6885448
112	552002	6885411
113	552338	6885395
114	552732	6885409
115	553059	6885401
116	553259	6885381
117	553547	6885329
118	553878	6885241
119	554269	6885094
120	554430	6884958
121	545579	6884826
122	554723	6884718
123	554026	6885186

This drawing has been produced using the "DEVELOPMENT AGREEMENT" Drawing 9700998-DA-Ex09-01 Rev. B, "Placement Areas" and Drawing No. 940172/13 Rev C "Stage 1B Nourishment Area design" from the Existing Section 86 Sanction dated 15 March 2001

NOTES

1. NEARSHORE BATHYMETRY BASED ON HYDROGRAPHIC SURVEY UNDERTAKEN BY GOLD COAST CITY COUNCIL IN DECEMBER 2014
2. ALL LEVELS ARE IN METRES RELATIVE TO AUSTRALIAN HEIGHT DATUM (AHD)
3. CO-ORDINATES ARE TO GDA 94 /MGA ZONE 56
4. REFER TO DRAWING DPA-3 FOR TIDAL INFORMATION
5. ALL CLEAR BOXES ARE EXISTING DEPOSITION AREAS
6. EXTENT OF KIRRA REEF BASED ON PHOTOGRAMMETRIC ANALYSIS OF AERIAL PHOTOGRAPHY CAPTURED IN APRIL 2013
7. DEPOSITION MATERIAL WILL BE CLEAN MARINE SAND AND TO COMPLY WITH THE FOLLOWING REQUIREMENTS:
   (I) 0.15mm < D50 < 0.35mm
   (II) CLAY/SILT < (0.075mm) <3%

CODE	DESCRIPTION	APPROVED

REVISIONS AND APPROVALS

QUEENSLAND GOVERNMENT
NSW GOVERNMENT Department of Primary Industries Lands

NSW DEPARTMENT OF PRIMARY INDUSTRIES
QUEENSLAND DEPARTMENT OF SCIENCE, INFORMATION TECHNOLOGY AND INNOVATION

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT
PERMITS AND APPROVALS
EXTENSION OF DREDGE PLACEMENT AREAS - PLACEMENT AREA 2B
PLAN

DATE: 27-07-2015
DRAWING NO: DPA-1
Rv:

LEGEND

-15 DECEMBER 2014 CONTOURS

MLWS (Dec 2014)

MHWS (Dec 2014)

A — B EXTENT OF PLACEMENT AREAS

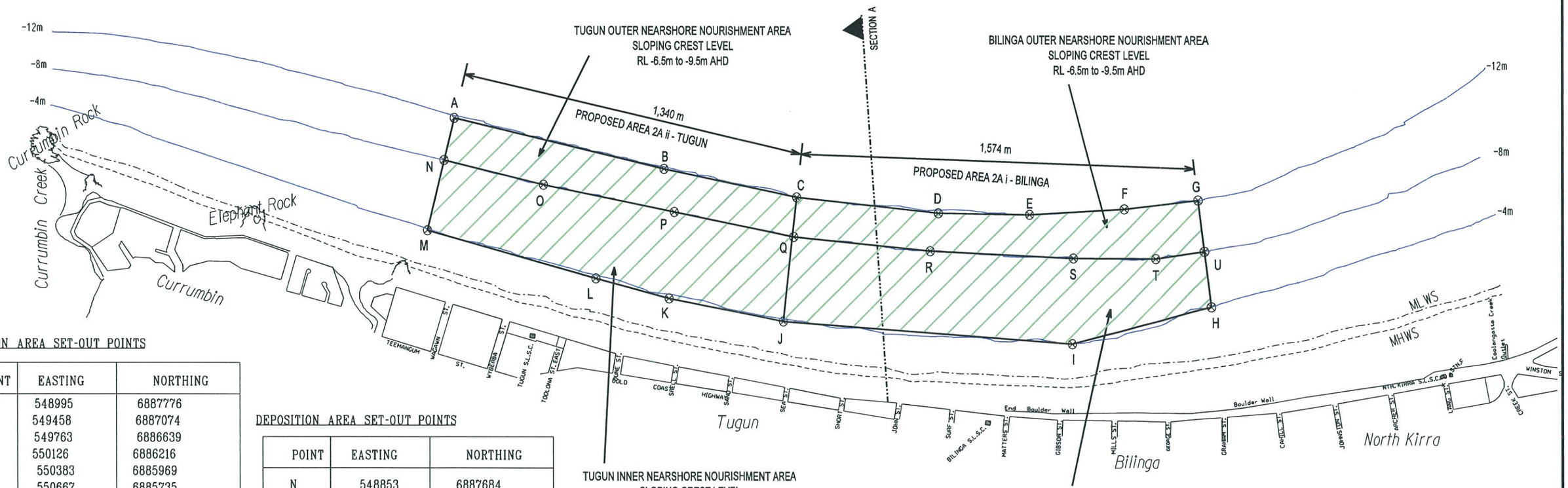
PROPOSED DREDGE PLACEMENT AREA

0 200 400 600m

SCALE

NOTES

1. NO BLASTING PERMITTED
2. REFER TO DRG. No. DPA-3 FOR SECTIONS
3. CO-ORDINATES SHOWN TO GDA 94 /MGA ZONE 56
4. ALL LEVELS ARE IN METRES REFERENCED AUSTRALIAN HEIGHT DATUM (AHD)
5. OFFSHORE BED CONTOURS ARE BASED ON SURVEY CARRIED OUT BY GOLD COAST CITY COUNCIL IN DECEMBER 2014
6. DEPOSITION MATERIAL WILL BE CLEAN MARINE SAND AND TO COMPLY WITH THE FOLLOWING REQUIREMENTS:
   (I) 0.15mm < D50 < 0.35mm
   (II) CLAY/SILT < (0.075mm) <3%



DEPOSITION AREA SET-OUT POINTS

POINT	EASTING	NORTHING
A	548995	6887776
B	549458	6887074
C	549763	6886639
D	550126	6886216
E	550383	6885969
F	550667	6885735
G	550907	6885558
H	550660	6885221
I	550162	6885488
J	549394	6886322
K	549128	6886693
L	548972	6886944
M	548619	6887529

DEPOSITION AREA SET-OUT POINTS

POINT	EASTING	NORTHING
N	548853	6887684
O	549071	6887350
P	549373	6886924
Q	549650	6886534
R	550002	6886131
S	550393	6885728
T	550627	6885507
U	550788	6885396

CODE	DESCRIPTION	APPROVED

REVISIONS AND APPROVALS

QUEENSLAND GOVERNMENT

NSW GOVERNMENT Department of Primary Industries Lands

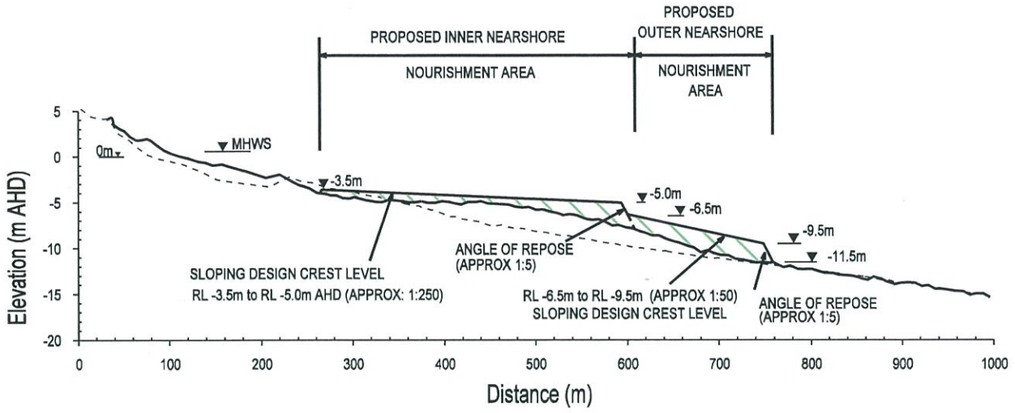
NSW DEPARTMENT OF PRIMARY INDUSTRIES
QUEENSLAND DEPARTMENT OF SCIENCE, INFORMATION TECHNOLOGY AND INNOVATION

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT
PERMITS AND APPROVALS
EXTENSION OF DREDGE PLACEMENT AREAS - PLACEMENT AREA 2A
PLAN

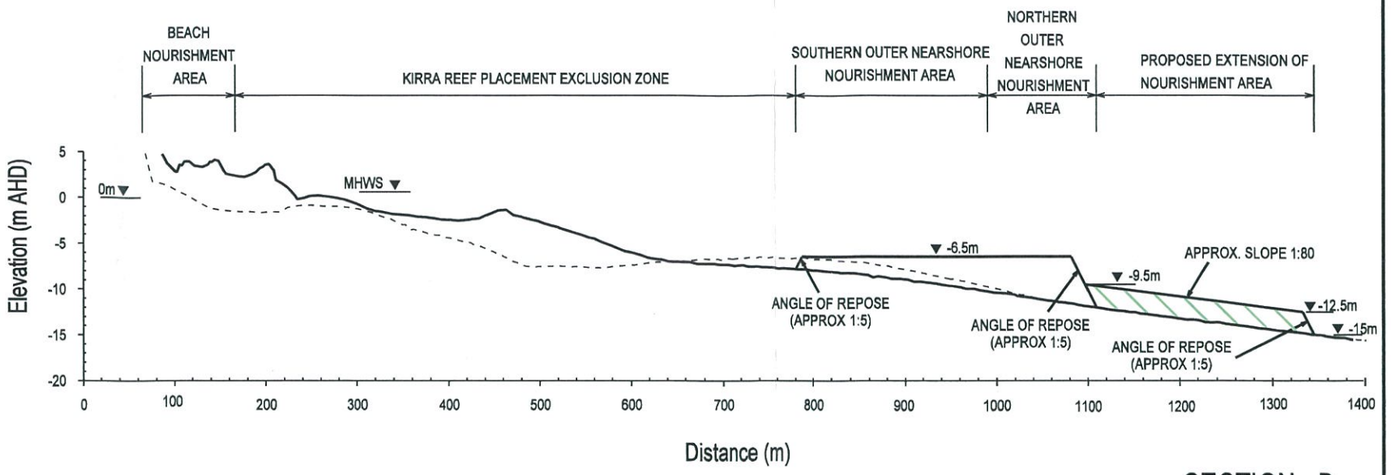
DATE: 27-07-2015

RV:

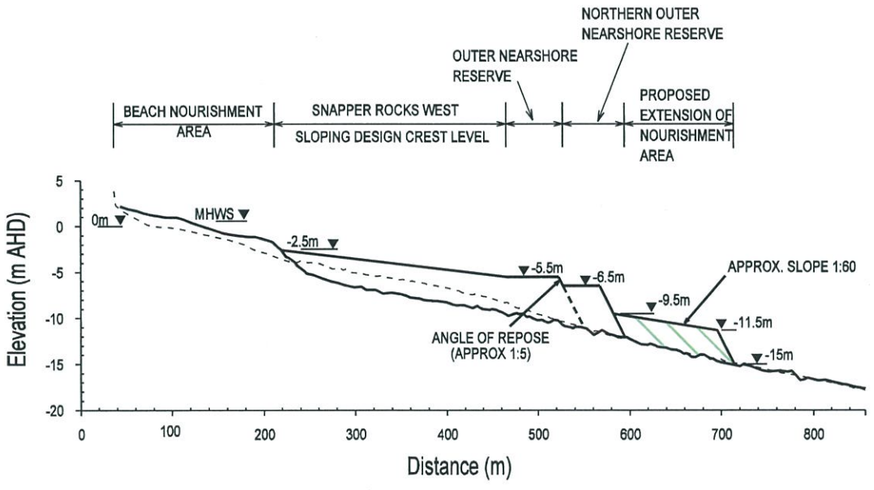
DRAWING NO:
DPA-2



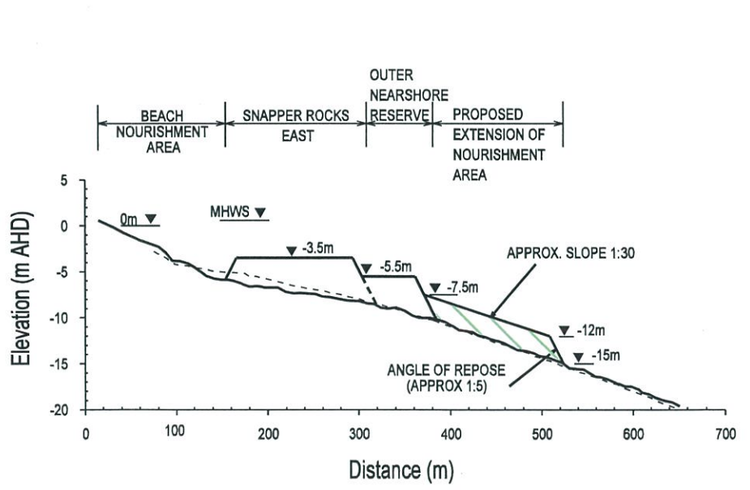
SECTION - A



SECTION - B



SECTION - C



SECTION - D

NOTES

1. NEARSHORE BATHYMETRY BASED ON HYDROGRAPHIC SURVEY UNDERTAKEN BY GOLD COAST CITY COUNCIL IN DECEMBER 2014
2. ALL LEVELS ARE IN METRES RELATIVE TO AUSTRALIAN HEIGHT DATUM (AHD)
3. CO-ORDINATES ARE TO GDA 94 /MGA ZONE 56
4. THE DESIGN SURFACE PROFILES SHOWN ARE INDICATIVE ONLY. RESULTANT ACTUAL PROFILES CAN NOT BE DEFINED DUE TO NATURAL DISPERSON BY WAVE ACTION.
5. DEPOSITION MATERIAL WILL BE CLEAN MARINE SAND AND TO COMPLY WITH THE FOLLOWING REQUIREMENTS:
   (I) 0.15mm < D50 < 0.35mm
   (II) CLAY/SILT < (0.075mm) < 3%

TIDAL INFORMATION

MEAN HIGH WATER SPRINGS	(MHWS)	0.586
MEAN SEA LEVEL AUSTRALIAN HEIGHT DATUM	(MSL) (AHD)	0
MEAN LOW WATER SPRINGS	(MLWS)	0.545

LEGEND:

- December 2014 survey profile
- March 2000 survey profile
- PROPOSED DREDGE PLACEMENT AREA

This drawing has been produced using the "DEVELOPMENT AGREEMENT" Drawing 9700998-DA-Ex09-02 Rev. D, "Placement Areas" and Drawing No. 940172/13 Rev C "Stage 1B Nourishment Area design" from the Existing Section 86 Sanction dated 15 March 2001

(HORIZ) 0 50 100 150 200 250 m

(VERT) 0 5 10 15 20 25 m

SCALE

CODE	DESCRIPTION	APPROVED

REVISIONS AND APPROVALS

QUEENSLAND GOVERNMENT

NSW Department of Primary Industries Lands

NSW DEPARMENT OF PRIMARY INDUSTRIES
QUEENSLAND DEPARTMENT OF SCIENCE, INFORMATION TECHNOLOGY AND INNOVATION

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT
PERMITS AND APPROVALS
EXTENSION OF DREDGE PLACEMENT AREAS - PLACEMENT AREAS 2A and 2B
SECTIONS

DATE: 27-07-2015

DRAWING NO: DPA-3

RV:

Appendix E
Aquatic ecological assessment

niche
Environment and Heritage

Tweed Sand Backpassing

Aquatic Ecology Assessment

Prepared for Adrill Payne & Partners

07 February 2019

Document control

Project no.:	3895
Project client:	Adrill Payne & Partners
Project office:	Sydney
Document description:	Aquatic Ecology Assessment - Desktop
Project Director:	Bruce Blunden
Project Manager:	David Cummings
Authors:	Dr David Cummings, Lucy Porter
Internal review:	Dr Amanda Griffith
Document status:	Rev2
Document address:	
Local Government Area:	Tweed Heads

Document revision status

Author	Revision number	Internal review	Date issued
David Cummings	D1	Amanda Griffith	23/11/2017
David Cummings	Rev2	Amanda Griffith	17/01/2019
David Cummings	Rev3	Amanda Griffith	07/02/2019

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 1, 19 Sorrell Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Email: info@niche-eh.com

Sydney
0488 224 888
Central Coast
0488 224 999
Illawarra
0488 224 777
Armidale
0488 224 094
Newcastle
0488 224 160
Mudgee
0488 224 025
Port Macquarie
0488 224 999
Brisbane
0488 224 036
Cairns
0488 284 743

Cover photograph: Tweed River Entrance

Executive summary

Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Ardill Payne & Partners (APP) to prepare an aquatic ecology assessment for the Tweed River Entrance Sand Bypassing Project (TSB) at Tweed Heads. This aquatic ecology assessment reviews the aquatic ecological constraints of the study area and assesses the impact of the proposal on aquatic flora and fauna. This aquatic ecology assessment provides information required to meet the assessment requirements stipulated under NSW State and Commonwealth legislation governing the conservation of fisheries, threatened species, populations and ecological communities. Assessments pursuant to the FM Act and/or BC Act and/or EPBC Act are provided as required.

The proposal area is near Fingal Head on the far North NSW Coast immediately south of Tweed Heads and the NSW/ QLD border. The assessment is based on desktop review of available information and database searches for threatened species and Matters of National Environmental Significance.

Review of available information and data indicated that soft sediment communities appear to constitute the majority of the benthic habitat within the proposal area. Searches of databases identified potential for over 150 threatened, migratory and protected marine species to occur in the vicinity of the proposal. Of these, 24 were considered further as part of the impact assessment as they were either known to occur or considered to have a high likelihood of occurrence in the study area.

The proposal has the potential to impact directly on soft sediment communities of infauna within the proposal area. Additional impacts may include adjacent habitats that include rocky reefs, the Cook Island Aquatic Reserve, and the adjacent beach. There is also potential for indirect impacts through reduced water quality from elevated levels suspended solids. This has the potential to impact on fauna such as birds, including migratory species, fish, mammals and sharks that may utilise the proposal area to forage, take refuge or more movement between important sites, and also flora and fauna, such as corals and macroalgae on adjacent reefs inside the Cook Island Aquatic Reserve. Noise and vessel operation associated with the proposal also has potential to result in disturbance of cetaceans, turtles and birds, especially birds that are known to breed and occasionally turtles, nearby. In addition, the interaction of marine fauna, especially air breathing fauna such as mammals, cetaceans and turtles with vessels can result in vessel strikes that can have fatal impacts on individual animals.

Recommendations to minimise and manage potential impacts of the proposal include:

- Avoid repeated deposition of spoil in one area to minimise potential for continuous impacts.
- Consideration of the rotation of deposition areas to allow benthic soft bottom communities to recover post-deposition.
- Adopt and adapt the Kirra Reef Biota Monitoring Program to include Cook Island. This should include inclusion of abiotic variables and collection of sufficient baseline dataset to account for temporal variability.
- Assessment of sediment contamination in accordance with the National Assessment and Guidelines for Dredging 2009 (DEWHA2009) if there are any changes to the dredge area or potential for/ suspected change in sediment quality /attributes from the proposed dredge area.
- Regular testing of waters within the Aquatic Reserve for TSS during deposition of sediments should be considered as part of the Environment protection licence (EPL) for the dredging works.

- Deposition of sediments with contaminants or substantially different characteristics to the those that naturally occur at the deposition site should be avoided.
- Avoid deposition of spoil in areas where seabirds or shorebirds (in adjacent intertidal areas at low tie) are foraging.
- Consult with local NPWS Office to avoid occurrences of nesting birds and turtles and minimise works in close proximity to Cook Island during breeding season.
- Adopt and adapt the NPWS guideline for approaching marine mammals to minimise vessel interactions with marine mammals, along with turtles and shorebirds.

The proposal is adjacent to the Cook Island Nature Reserve and in close proximity to the Cook Island Aquatic Reserve. These reserves include a number of threatened and migratory species with both State and Commonwealth significance. Thus, measures to avoid, minimise or mitigate potential for impacts on these reserves should be considered carefully as part of this proposal.

The proposal is considered unlikely to have a significant impact on State and/or Commonwealth listed threatened biodiversity, or MNES. Referral to the Department of the Environment under the EPBC Act is not required. Similarly, the preparation of a species impact statement (SIS) based on the provisions of the BC Act or FM Act is not required.

Glossary and abbreviations

BC Act	*Biodiversity Conservation Act 2016*
CAMBA	China Australia Migratory Bird Agreement
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
Flora and fauna of conservation significance	Threatened species or populations listed on the schedules of the TSC Act and/or listed as matters of National Environmental Significance (NES) under the EPBC Act
FM Act	NSW *Fisheries Management Act 1994*
JAMBA	Japan Australia Migratory Bird Agreement
Local occurrence	Refers to the distribution of an ecological community within the study area and continuous with it
Local population	The population of a particular threatened species that occurs in the locality
Locality	The area within 10 km of the study area
Key fish habitat	Habitats important for fisheries conservation
KTPs	Key Threatening Processes
Macroinvertebrates	Benthic infauna that live within the estuarine sediments
MNES	Matters of National Environmental Significance
MEM Act	*Marine Estate Management Act 2014*
Microphytobenthos	Benthic microalgae, occurs on intertidal and sub-tidal sediments and can form inconspicuous films.
DPI	NSW Department of Primary Industries
OEH	Office of Environment and Heritage
OISAS	NSW Oyster Industry Sustainable Aquaculture Strategy
SEPP	State Environment Planning Policy
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SEPP14	State Environmental Planning Policy No. 14 – Coastal Wetlands
TEC	Threatened ecological community as listed on the TSC Act and or EPBC Act. Collective term to describe vulnerable, endangered and critically endangered ecological communities
Threatened biodiversity	Threatened species, populations and ecological communities as listed on the TSC and or EPBC Acts
TSS	Total Suspended Solids

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Ardill Payne & Partners (APP) to prepare an aquatic ecology assessment for the Tweed River Entrance Sand Bypassing Project (TSB) at Tweed Heads. This aquatic ecology assessment reviews the aquatic ecological constraints of the study area and assesses the impact of the proposal on aquatic flora and fauna.

1.2 Purpose of this report

This aquatic ecology assessment is designed to provide information required to meet the assessment requirements stipulated under NSW State and Commonwealth legislation governing the conservation of fisheries, threatened species, populations and ecological communities. Assessments pursuant to the Fisheries Management (FM) Act and/or Biodiversity Conservation (BC) Act and/or Environment Protection and Biodiversity Conservation (EPBC) Act are provided as required.

1.3 Investigation scope

The preparation of this report involved the following tasks:

- Review of relevant data, mapping and reports.
- Desktop searches for threatened species, populations and communities listed under the FM, BC and EPBC Acts.
- Identification and description of potential impacts from the proposal.
- Consideration of the "avoid, mitigate and offset" principles.
- Preparation of impact assessments under the EP&A Act and EPBC Act for threatened biodiversity deemed relevant to the proposal.

Given the volumes of sand to be placed in the deposition area (See Section 1.5) the Department of Industry (DOI) has advised that a desktop study is sufficient for this proposal.

1.4 Proposal area

The proposal area is near Fingal Head on the far north NSW Coast immediately south of Tweed Heads and the NSW/ QLD border (Figure 1). The Cook Island Aquatic Reserve Surrounds Cook Island, which is located approximately 600 metres offshore from Fingal Head. The proposal lies outside the nearby Cook Island Aquatic Reserve Boundary.

The deposition areas are located parallel to the beach, between the 3 m and 13 m depth contours adjacent to Fingal Beach and Dreamtime Beach.

A summary of the major geophysical features of the study area is presented in Table 1 below.

Table 1. Geophysical context of the study area

Geographical feature	Description
Bioregion	North Coast
LLS region	North Coast
Local government area	Tweed Heads
Estuary / watercourses	NA
Nearby conservation areas	Cook Island Nature Reserve, Cook Island Aquatic Reserve

1.5 Description of the proposal

NSW Department of Industry are proposing the backpassing of sand toward the "upstream" direction of net coastal longshore sediment transport in the region. This ensures that sand remains within the active coastal zone and is not lost from the total sediment budget. Backpassing will be an option that the project may consider as a stand-alone activity or as part of a wider dredge campaign.

The areas to be nourished include the Fingal Beach deposition area north of Fingal Head (Figure 2), and the Dreamtime Beach deposition area south of Fingal Head (Figure 3). The deposition areas are located parallel to the beach, approximately between the 3 m – 13 m depth contours. The proposal is for a nominal annual placement of 50,000 m^3 across both deposition areas and this is inclusive of a 20,000 m^3 restriction at Dreamtime Beach.

The proposal will result in raising the seabed profile by up to 0.5 m (-4 m to -3.5 m) nearest the beach, and up to 2 m (-12.5 m to -10.5 m) along the seaward extent of the sand deposition area. See Appendix 1 for detailed design and profiles.

Details of a typical backpassing by dredge campaign assuming the proposed placement volumes as detailed above are as follows:

- The sand will be deposited by the dredge vessel (approximately 50 m in LOA)
- A return transit, dredging, positioning and placement time of approximately 60 minutes to Fingal Beach and 80 minutes to Dreamtime Beach is expected
- Placement rates of three400m^3 loads per day are expected. 3 x 1800 m^3
- Considering 20% downtime due to weather, expected annual operations are 30 days to Fingal Beach and 20 days to Dreamtime Beach. 11 17 57% STAND-BY DAYS

The proposal has the potential to have the following impacts on aquatic ecology:

- Smothering of organisms
- Increases in turbidity, suspended solids, and potential contaminants in water sediments
- Modification of intertidal and shallow water habitats
- Introduction and/or spread of noxious or invasive species
- Disturbance of fauna from vessel noise and increased risk of vessel strike.

1.6 Legislative context

The following legislative context has been considered in this assessment:

- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)
- NSW *Fisheries Management Act 1994* (FM Act)
- NSW *Biodiversity Conservation Act 2016* (BC Act)
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The legislative context for the assessment is outlined in the following sections.

1.6.1 EP&A Act

The EP&A Act provides an assessment framework for the consideration of threatened species, populations, ecological communities and their habitats. Section 5A of the EP&A Act lists seven factors to be considered when projects are deemed to have an impact on the habitat of threatened biodiversity listed on the FM Act or BC Act. The assessment of significance, or seven-part test, sets the criteria for determining whether a

proposal is likely to have a significant impact on threatened biodiversity listed under the FM Act that, if this is identified, would necessitate the preparation of a species impact statement (SIS).

1.6.2 FM Act

The main objectives of the FM Act are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations, and in particular:

- To conserve fish stocks and key fish habitats.
- To conserve threatened species, populations and ecological communities of fish and marine vegetation.
- To promote ecologically sustainable development, including the conservation of biological diversity and, consistently with these objectives.
- To promote viable commercial fishing and aquaculture industries.
- To promote quality recreational fishing opportunities.
- To appropriately share fisheries resources between the users of those resources.
- To provide social and economic benefits for the wider community of NSW.
- To recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

To meet the primary objectives, Part 7 of the FM Act deals with the protection of aquatic habitats and Part 7A deals with threatened species conservation. Part 7 commonly applies to dredging and reclamation works, protection of marine vegetation including mangroves, and protection of spawning of certain fish, and noxious fish and marine vegetation. Many of the above activities will require a permit under Part 7 of the FM Act.

Threatened species, populations and ecological communities' listings gazetted under the FM Act are relevant to this assessment. Threatened biota impacted by the proposal must be assessed under section 5A of the EP&A Act.

Key fish habitat policy

The waterways within the study area fall within the definition and are mapped as 'Type 3 – Minimally sensitive key fish' (Fairfull 2013). NSW DPI recognises that certain types of activities have varying degrees of impact on key fish habitats and, as such, require different levels of control and regulation. As a general principle, NSW DPI requires that proponents should, as a first priority, aim to avoid impacts upon key fish habitats. Where avoidance is impossible or impractical, proponents should then aim to minimise impacts. For any remaining impacts consideration is to be given to establishment of suitable offsets or compensation.

1.6.3 BC Act

The BC Act provides for legal protections of biodiversity and threatened species in NSW. It provides for:

- A process for declaring and protecting areas of outstanding biodiversity value.
- The listing of 'threatened species, populations and ecological communities, with critically endangered, endangered and vulnerable species, listed under Schedule 1.
- The listing of critically endangered, endangered and vulnerable ecological communities listed under Schedule 2, and extinct species, species extinct in the wild and collapsed ecological communities of animals and plants listed under Schedule 3.
- Requirements for the preparation of a species impact statement (SIS).

- Sets the criteria for determining whether a proposal is likely to have a significant impact on threatened biodiversity listed under the BC Act that, if this is identified, would necessitate the preparation of a species impact statement (SIS).

Threatened species, populations and ecological communities listed under the BC Act are relevant to this assessment. Threatened biota impacted by the proposal can be assessed under section 5A of the EP&A Act, where the proponent is the consent authority.

1.6.4 EPBC Act

The purpose of the EPBC Act is to ensure that actions likely to cause a significant impact on matters of national environmental significance undergo an assessment and approval process. Under the EPBC Act, an action includes a project, undertaking, development or activity. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is deemed to be a controlled action and may not be undertaken without prior approval from the Commonwealth Minister for the Department of Environment (DoE).

The EPBC Act identifies matters of national environmental significance (MNES) as:

- World heritage properties
- National heritage places
- Wetlands of international importance (Ramsar wetlands)
- Threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)
- The Great Barrier Reef Marine Park
- A water resource, in relation to coal seam gas development and large coal mining development.

Listings deemed relevant to the proposal are to be assessed in accordance with relevant guidelines available at the time of writing the assessment.

2. Methodology

2.1 Database searches

Database searches for a 10 km radius around the study area were conducted in January 2019 (of "all records") to identify threatened biodiversity and migratory species with known or potential occurrences in the locality. The following databases were used for this purpose:

- Fisheries Spatial Data Portal (DPI 2017a)
- Bionet, Atlas of NSW Wildlife (OEH 2019a)
- EPBC Act Protected Matters Report tool (DoE 2019a)
- Species Profile and Threats Database (DoE 2019a).
- Threatened Species Profiles for threatened species, endangered populations and endangered ecological communities listed under the BC Act (OEH 2019b)

2.2 Threatened flora and fauna likelihood of occurrence

A list of threatened terrestrial and aquatic flora and fauna within the locality (10km radius) was determined from database searches described in section 2.1. The list of potentially impacted (affected) species is determined from consideration of this list.

In order to adequately determine the relevant level of assessment to apply to potentially affected species, further analysis of the likelihood of those species occurring within the study area was completed.

Five categories for 'likelihood of occurrence'(Table 2) were attributed to species after consideration of criteria such as known records, presence or absence of important habitat features on the subject site, and professional judgement. This process was completed on an individual species basis.

Species considered further in formal assessments of significance (FM, TSC and/or EPBC Acts,) legislation were those in the 'Known' to 'High' categories for likelihood of occurrence, as well as those in the moderate category where impacts for the species could reasonably occur from the development. Species listed as a 'low' or 'no' likelihood of occurrence are those for which there is limited habitat present within the study area.

Table 2 Likelihood of occurrence criteria

Likelihood rating	Threatened flora criteria	Threatened and migratory fauna criteria
Known	The species was observed within the study area.	The species was observed within the study area.
High	It is likely that a species inhabits or utilises habitat within the study area.	It is likely that a species inhabits or utilises habitat within the study area.
Moderate	Potential habitat for a species occurs on the site. Adequate field survey would determine if there is a 'high' or 'low' likelihood of occurrence for the species within the study area.	Potential habitat for a species occurs on the site and the species may occasionally utilise that habitat. Species unlikely to be wholly dependent on the habitat present within the study area.
Low	It is unlikely that the species inhabits the study area.	It is unlikely that the species inhabits the study area. If present at the site, the species would likely be a transient visitor. The site contains only very common habitat for this species which the species would not rely on for its on-going local existence.

None	The habitat within the study area is unsuitable for the species.	The habitat within the study area is unsuitable for the species.

2.3 Review of existing information

The following previous reports and documents were reviewed to assist in describing the existing environment and potential impacts:

- Permanent Bypassing System: EIS (Hyder Consulting *et al* 1997).
- Kirra Reef Biota Monitoring Project 2017: Tweed River Entrance Sand Bypassing Project (FRC Environmental 2017a).
- Tweed River Sediment Analysis Report: Supporting information for approvals Feasibility Option 2A/2B works (DSITI 2016).
- Tweed River Entrance Sand Bypassing Project: Proposed Dredged Sand Placement Areas 2A, 2B and Snapper Rocks Reef EPBC Self-Assessment (FRC 2017b).
- Cook Island Nature Reserve Plan of Management (NPWS 2011).
- Sea Turtle Ecology of the Gold Coast Region, Australia: Habitat use, foraging behaviour and movement patterns (Cuttriss 2014).
- Seabed habitat mapping of the continental shelf of NSW (DECC 2010).
- Tweed Quantified Conceptual Sediment Transport Model (Jacobs 2017).
- Sediment Investigation Report: Lower Tweed River Maintenance Dredging (Hydrosphere Consulting 2015).

In addition, the following imagery and data was used to assist in describing the existing environment and potential impacts:

- Aerial imagery provided by DOI Lands (November 2017).
- Aerial imagery of the proposal area available from Nearmap between 2010 and 2017.
- LIDAR data supplied by DOI Lands (November 2017).
- Backpass design profiles and placement areas provided by DOI Lands (November 2017).

2.4 Limitations

This assessment is limited to desktop review only. The findings of this assessment are reliant on the accuracy of the information available.

3. Review of Existing Information

3.1 Ecology

An EIS for the Tweed River Sand Bypassing System was undertaken in 1997. This report identified two dominant coastal benthic habitats in the vicinity of the Tweed River mouth. This included vegetated sandy soft bottom communities and rocky outcrops (Hyder Consulting *et al* 1997).

Soft sediment communities appear to constitute the majority of the benthic habitat within the proposal area. The soft sediment communities in the nearshore zone are heavily influenced by moderate to high wave energy resulting in high mobility of sand. Sampling of sediments in the vicinity of Tweed River mouth entrance identified infauna communities to be dominated by small crustaceans (amphipods, isopods, decapods, and cumaceans) (Hyder Consulting *et al* 1997).

Previous reports and investigations have not identified any rocky outcrops between the Tweed River Mouth and Cook Island Aquatic Reserve to the south. The Cook Island Aquatic Reserve is a known nesting area for birds and includes a complex underwater reef system that extends seaward (DPI 2017b). Cook Island is also a Nature Reserve gazetted in 1959. The island is known breeding habitat for shorebirds and seabirds, in particular the Crested Tern and Wedge-tailed Shearwater (NPWS 2011). Numerous migratory species that also roost and forage on and in the waters surrounding the Cook Island Nature Reserve are also protected by international agreements of CAMBA, JAMBA and ROKAMBA for migratory birds. The Aquatic Reserve boundary and associated reefs lie outside the proposal area. Previous surveys of reef communities at Cook Island have recently been undertaken as part of monitoring for Kirra Reef north of the Tweed River. Hard Corals and turfing algae are described to dominate reef assemblages around Cook Island, with a diverse assemblage of over 50 reef fish species (FRC 2017b).

3.2 Sediments

A recent study done by Jacobs (2017) documenting the conceptual sediment transport model described the sand supply to Letitia Spit to occur mostly as episodic 'slugs' of large quantities of sand over a short period of time past Fingal Head, with a predominately northerly littoral transport adjacent to Fingal Beach. With the East Australian Current typically sweeping sand back into Dreamtime Beach from around the reefs adjacent to Cook Island. These episodic 'slugs' are likely to be associated with storm events and large waves resulting in accumulations of sand at the northern end of Dreamtime Beach, and subsequently then being transported around the headland by littoral transport (Jacobs 2017). However, persistent sand transport away from the headland on both sides (in both a southerly and northerly direction) occurs following prevailing winds, resulting in the area becoming eroded with exposed bed rock immediately south and east of Fingal Head, and ceasing the northerly transport of sediment. As a result, considerable variability in sand transport past Fingal Head occurs (Jacobs 2017). Given this, natural sedimentation of reefs and habitat around the Cook Island and Fingal Head are likely to be naturally occurring and episodic. As a result, these episodic sediment movements are likely large natural drivers of the reef communities and changes in their assemblage in this area.

The sediments from the Tweed River bar, (where the dredging of the material is proposed) have previously been described as bare sands that are predominately fine sands (DSITI 2016). More, recent investigations have documented sediment characteristics nearby in the lower Tweed River. These sediments were proposed to be dredged to maintain the navigable channel and nourish the adjacent Fingal Beach. These

sediments were found to predominantly sand with some shell material present with a similar nature to those sediments at the placement location, and no evidence of contamination (Hydrosphere Consulting 2015). It is likely sediments that accumulating nearby and down river, on the Tweed River bar which is proposed to be dredged for these works are similar and contaminant free.

3.3 Mapping and aerial imagery

Previous seabed mapping of the area using LIDAR imagery shows the nearshore zone along Fingal and Dreamtime Beaches to have minimal seabed structure in the proposal area, with benthic habitat appearing uniform and generally gradually sloping. This indicates that the nearshore habitat in these areas is a sandy soft sediment habitat. Reef habitat is restricted to within proximity to Cook Island and then extends into deeper areas seaward of both Cook Island and the proposal areas (Based on data supplied by DOI spoil

Lands 2017) (Figure 4). This coincides with mapping work done along the NSW Coast that describes the habitats around Fingal Head and Dreamtime Beaches as large ocean beaches with soft sediment habitat (DECC 2010).

A review of aerial imagery since 2010 sourced from Nearmap indicated that some additional rocky areas along the beach on the very southern end of Fingal Head Beach may occur. These rocky areas are of very low rugosity, likely consist of gravel, rubble and bedrock, and may appear and disappear regularly. This area appears to be very dynamic in nature, with constant changes to the beach line, resulting in regular covering by sand and at the times the beach (Figure 5).

4. Biodiversity and Key Threatening Processes

4.1 Ecological communities, threatened and migratory species

Searches of threatened species and ecological communities, including migratory species, identified one ecological community, 84 estuarine species of birds (including migratory species), 37 fish species, 20 marine mammal species (including migratory species), eight species of reptiles, nine shark and ray species, and one plant (Appendix 1).Searches of the NSW Office of Environment and Heritage Bionet Atlas found records of 26 species within a 10km radius (Figure 6). Of all 84 species, 24 were considered further as part of the impact assessment as there was a moderate to high likelihood of occurrence or they are known to occur in the study area (Table 3).

Table 3 Listed species and communities requiring further consideration as part of the impact assessment

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Likelihood of occurrence	Potential for impact
Esacus neglectus	Beach Stone-curlew	CE	MA		Known	Possible – Forage and roost nearby. May breed in the area.
Ephippiorhynchus asiaticus	Black-necked Stork	E	-		High – has been sighted along the beach to the south	Unlikely – Foraging habitat is marginal
Thalasseus bergii	Crested Tern		M, MA		Known	Possible – Forage and roost nearby. Breeds on Cook Island.
Charadrius bicinctus	Double-banded Plover	-	M		High	Possible – Forage and roost nearby.
Numenius madagascariensis	Eastern Curlew	-	CE, MA, M		High	Possible – Forage and roost nearby.
Pandion cristatus, Pandion haliaetus	Eastern Osprey	V	M, MA		High	Possible – Foraging habitat within the study area
Puffinus carneipes *Ardenna carneipes*	Flesh-footed Shearwater	V			Known	Possible – Breed on Cook Island, potential foraging habitat.
Sternula albifrons	Little Tern	E	M		Known	Possible – Forage and roost nearby. May breed in the area.
Haematopus longirostris	Pied Oystercatcher	E	-		Known	Possible – Forage and roost nearby. May breed in the area.
Chroicocephalus novaehollandiae	Silver Gull		MA		Known	Possible – Forage and roost nearby. May breed in the area.
Haematopus fuliginosus	Sooty Oystercatcher	V			Known	Possible – Forage and roost nearby. May breed in the area.
Arenaria interpres	Ruddy Turnstone	-	M		High	Possible – Forage and roost nearby.

Scientific Name	Common Name	BC Act	EPBC Act	FM Act	Likelihood of occurrence	Potential for impact
Numenius phaeopus	Whimbrel	-	M		High	Possible – Forage and roost nearby.
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	MA		High	Likely – Foraging habitat will likely occur within the study area
Ardenna pacifica	Wedge-tailed Shearwater		M, MA		Known	Possible – Breeds on Cook Island, foraging habitat within the study area
Epinephelus daemelii	Black Rockcod		V	V	Known	Possible – May forage in the area
Carcharius taurus	Grey Nurse Shark		E	CE	Known	Possible - May forage in area
Carcharodon carcharias	Great White Shark		V, MA	V	High	Unlikely – Are likely to forage in area at times but potential to impact on the species from this action is minimal.
Megaptera novaeangliae	Humpback Whale	V	V, M		High	Unlikely – Mostly transient in area, may rest in area at times
Tursiops aduncus	Spotted Bottlenose Dolphin		M		High	Possible – Likely to be present at times
Tursiops truncatus	Bottlenose Dolphin		M		High	Possible – Likely to be present at times
Chelonia mydas	Green Turtle	V	V, M		Known	Possible – May forage in the area, may breed nearby on beach
Eretmochelys imbricata	Hawksbill Turtle		V, M		Known	Possible – May forage in the area
Caretta caretta	Loggerhead Turtle	E	E, M		Known	Possible – May forage in the area, may breed nearby on beach

4.2 Protected species

In NSW all species of fish that belong to the Syngnathidae family are protected under the FM Act. This group of fish includes seahorses, seadragons, pipefish, pipehorses, ghostpipefish and seamoths. Major threats to these fish include pollution, habitat loss and ornamental collection and trade. These species are small, can be cryptic, have a small home range, and typically occur where adequate refuge habitat exists such as seagrasses, macroalgae beds or structures.

The Giant Queensland Groper (*Epinephelus lanceolatus*) is reported to occur in the Cook Island Aquatic Reserve while the Estuary Cod (*Epinephelus coioides*) may also occur. These species are likely to use caves associated with reef habitat and drop-offs within the Aquatic Reserve (NSW DPI 2006a and 2006b). Both the Giant Queensland Groper and Estuary Cod are large predatory species, which are likely to use adjacent habitats to forage for prey at times.

4.3 Key threatening processes

Two key threatening processes were identified to be of relevance for the proposed works (Table 4). These are considered further as part of the impact assessment.

Table 4 Key threatening processes

Key Threatening Process	BC Act/FM Act	EPBC Act	Section
Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris	√	√	5.5
Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales	√		5.6

5. Impact Assessment

5.1 Habitat

5.1.1 Soft bottom communities

The majority of benthic habitat impacted by this proposal supports un-vegetated, sandy communities. There is potential for direct impacts on the infauna community. Impacts on this community type will likely result in some changes to the benthic infaunal assemblage. These changes will be dependent on existing species composition, depth of sand deposited on the seafloor, composition of spoil, and frequency of deposition. The deposition of clean marine sand on sub-tidal areas will bury and selectively kill populations of benthic invertebrates, or indirectly alter assemblages by modifying sediment characteristics (Bishop *et al* 2006). Previous research has indicated that infauna associated with shallow sub-tidal areas of beaches typically recovers between six months and two years following nourishment works (Menn *et al* 2003). Continuous use of the deposition areas may potentially result in longer term changes to infauna communities in these areas, as they are unlikely to gain the opportunity to recover.

The existing coastal processes and sediment transfer patterns that occur at the deposition sites will also influence the impact of the sand on infauna. Previous research has found that constant deposition of sand in a dynamic sedimentary environment disperses the sand and mixes it with the ambient sediments (Roberts and Forest 1999). In the proposal area, there is potential that the dynamic nature of the environment may assist in minimising potential impacts on the infauna assemblage. This is supported by the conceptual sediment transport model, which describes the area as having very variable levels of sediment transport and deposition (Jacobs 2017). Furthermore, the proposal represents a sand volume of less than 10% per annum of the long term averaged (LTA) longshore sediment transport (LST) along the coast (Pers Com: Matthew Harry, Senior Coastal Management Specialist - Tweed Sand Bypass, December 2018). Given that the proposal is only for small placement volumes in comparison to the natural transport rate, which will likely be dispersed quickly through the natural sediment transport pathways, and sediment deposition will be spread throughout the deposition areas, continuous and cumulative impacts on infauna will likely be minimal.

Analysis of sediments from the Tweed River bar, (where the dredging of the material is proposed) describe sediments as bare sands that are predominately fine sands (DSITI 2016). It is likely, these sands are similar to those in the deposition areas to the south of the Tweed River bar. Biological impacts on infauna have found to be lesser for courser sands and those which are most similar to the receiving environment (Bishop *et al* 2006). This may also reduce the potential for long-term changes in the infauna assemblages within the deposition areas. The deposition of sand will also create new habitat, that will be colonised by benthic animals. This colonisation process typically occurs by the settlement of propagules via the water column or migration of benthic fauna from nearby colonised areas (TEL 2011). Ultimately the deposition of sediment in these areas is likely going to be comparable, if not less than, the naturally occurring episodic events.

5.1.2 Rocky reef areas

Based on desktop review there appears to be minimal rocky substrate areas in the proposal area. Rocky substrate that may occur at times on the southern section of Fingal Head Beach, which may be directly impacted by this proposal. These areas appear in very shallow water, may be intertidal at times, and appear to be frequently covered in sand. Based on the conceptual sand transport model, the occurrence of these rocky substrates around Letitia Spit, are the result of eroding of sediment away from Fingal Head (Jacobs 2017). The smothering of rocky substrate from the proposal at the southern end of the Fingal Beach

deposition area in shallow areas adjacent to the beach is likely reflective of the natural sediment transportation and deposition patterns in the study area. Given that there appears to be a frequent natural deposition of sand in these areas, and any hard reef-like substrate is likely of minimal rugosity, any substantial sessile reef biota that is sensitive to smothering is likely to be absent. Review of aerial imagery indicates that the most potential to impact on rocky reef areas is on the southern side of the Fingal Beach deposition area. In this area some permanent reef associated with the Cook Island Aquatic Reserve is evident on aerial imagery at approximately 200 m from the proposed deposition boundary. Further indirect impacts due to water quality and sedimentation may also impact on nearby reefs. These have been further discussed below in Section 5.4.

5.2 Cook Island Nature Reserve

Cook Island is an important breeding and roosting site for some species of shorebirds and seabirds. This includes migratory species protected by international agreements under the EPBC Act such as CAMBA, JAMBA and ROKAMA. These species include the Crested Tern and Wedge-tailed Shearwater which are known to breed on the Island, while searches found a record of the Sooty Oystercatcher breeding on the Island. Many other species including migratory species are likely to roost on the island and utilise feeding habitat in the surrounding waters, which can be indirectly impacted from reduced water quality. Migratory bird species that utilise the waters and Island of the Cook Island Nature Reserve are also protected under numerous bilateral agreements for migratory birds. Potential impacts to shorebirds and seabirds are discussed further in Section 5.8.

The conceptual model indicates that the migration of sediments will likely be in a northerly direction adjacent to the beach and pass between Fingal head and Cook Island. The migration of sediments to more substantial areas of reef to the north and east of Cook Island is not expected (Jacobs 2017). Thus, habitat adjacent to Cook Island impacted by this proposal is expected to primarily be areas on the Letitia Spit and within the natural sediment pathways driven by dominant winds and currents (see Jacobs 2017 for further information).

5.3 Sediment quality

Sediment quality includes physical characteristics and composition, nutrients, chemicals and potential contaminants. These characteristics all have potential to have direct impacts on fauna that occur in the study area, specifically infauna and fish, as well as transient fauna, mammals, birds and reptiles, and indirect impacts on the surrounding aquatic environment. Analysis of sediments to be dredged did not detect any concentrations of contaminants above the sediment quality guidelines. It was concluded that the sediments were considered non-toxic, and suitable for unconfined ocean disposal (DSITI 2016). Furthermore, the sediments were described as bare sands and likely similar to clean marine sands in the deposition areas to the south of the Tweed River bar. Based on this finding, the potential for impacts on aquatic flora and fauna from sediment quality will likely be minimal.

5.4 Water quality

Changes in water quality have the potential for direct and indirect impacts. Assuming the sediments are clean sands and contaminant free, the changes in water quality will be confined to potential for elevated turbidity, and levels of suspended solids within the water column. This has potential to have direct impacts on fauna that live or utilise habitat with in the deposition area, and in indirect impacts on the surrounding habitat that may include reefs. Turbidity can limit the growth of primary producers, which require light, such as microalgae and phytoplankton, effect gaseous exchange in aquatic organisms, impact on foraging, and over time is expected to reduce biodiversity in aquatic systems. In coastal areas turbidity is known to

effect foraging success of visual foraging predators such as aerial seabirds, some fish, shark, ray, mammal, and reptile species (Lunt and Smee 2015). The potential impacts of turbidity on these species is discussed further in Section 5.8.

Suspended solids also have pronounced impacts on aquatic systems as they settle out from the water column. They may directly impact the quality of and biodiversity amongst aquatic habitats. The Cook Island Aquatic Reserve is an extensive reef system, which includes an abundance of sessile reef taxa sensitive to sedimentation that include hard corals. In high energy areas, similar to those around Cook Island, sedimentation has been found to increase the rate of succession from hard coral to algal turf dominated habitats (Goatley and Bellwood 2013). Thus, given the proposal is in close proximity to the Cook Island Aquatic Reserve and potential reefs with hard coral cover, any elevated levels of suspended solids may impact on the habitat quality and biodiversity of nearby reefs including those within the Cook Island Aquatic Reserve, especially where hard corals are abundant.

The visible sediment plume from this proposal will be influenced by deposition method and amount, ocean conditions (wind, waves and current) and sediment characteristics. Previous placement of dredge material in similar depths at Cronulla Beach resulted in a plume of less than 50 m from the point of deposition (TEL 2011). It is likely that a similar sized plume will be experienced from the deposition of sediments adjacent to Fingal and Dreamtime Beaches.

5.5 Waste, spills and debris

Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is considered a Key Threatening Process under both the FM Act and EPBC Act. Petroleum products destroy the insulating ability of fur-bearing mammals, such as seals, and the water repellency of a bird's feathers, while they can also have an effect on the health, fitness, condition, growth rates, and larval survival of fish and invertebrates. The planned or unplanned disposal of any wastes, petroleum-based products and debris has potential to have direct and indirect impacts on marine fauna in the proposal area. Given that no wastes are planned to be disposed except the spoil, which is expected to be relatively debris free, this will have minimal potential impact on aquatic flora and fauna.

5.6 Introduced and noxious species

The introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW is considered a Key Threatening Process under the FM Act. Introduced fish and marine vegetation or noxious (invasive or toxic) species that may occur amongst dredge material (e.g. toxic dinoflagellates) and/ or on equipment, can pose risk of an introduction of an introduced or noxious species. Given that the dredge material is described as bare sand, and is from close proximity to the deposition areas, there is minimal risk of introduction of an introduced or noxious species from the proposal. However, introduced or noxious species that are growing attached to the hull of the dredging and associated vessels remain a risk for a new introduction to the proposal area.

5.7 Flora

5.7.3 Threatened ecological communities

The proposal is not expected to have any impacts on communities that occur above tidal limits of the shoreline or estuarine based communities, such as the endangered Coastal Saltmarsh.

5.7.4 Plants

The proposal is not expected to have any impacts on plants that occur above tidal limits of the shoreline. The adjacent shoreline does not include any intertidal trees e.g. mangroves. The habitat in the proposal area and adjacent habitats is a high energy coastal area of open beach that is not suitable for the establishment of seagrasses.

5.7.5 Algal communities

Algal communities in the proposal area are restricted to microalgae that may grow amongst soft sediments. Given that the sediments are typically coarse (bare sands) in the area, and it is within a highly dynamic zone near the beach, the presence of any benthic microalgae will be minimal.

Macroalgae stands are known to occur throughout the adjacent reef complex that occurs within the Cook Island Nature Reserve, and likely to be present around the rocky shore of Fingal Head. Impacts on water quality, such as sedimentation has the potential to impact on macroalgae stands amongst nearby reefs and rocky shores. Sedimentation has been found to impact macroalgae species with shorter reproductive periods or minimal dispersal capability through fragmentation (Eriksson and Johansson 2005). Given the area around Fingal Head is highly dynamic, and sediment transfer known to be very active, there is likely minimal potential for impact on any macroalgae around Fingal Head. However, macroalgae stands in more protected areas around Cook Island and inside the Aquatic Reserve may require further consideration where elevated levels of suspended solids occur in the vicinity of these reefs.

5.8 Fauna

5.8.6 Threatened species

Birds

The proposed action considered in this assessment has potential to impact on shorebirds through disturbance e.g. noise during breeding, roosting and foraging, and impacting on the quality of foraging habitat. Shorebirds utilise estuarine or shoreline habitat at low tide to forage. Shorebird species that may utilise habitat along Fingal Beach with potential to be impacted include the Beach Stone-curlew (*Esacus neglectus*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Double-banded Plover (*Charadrius bicinctus*), Eastern Curlew (*Numenius madagascariensis*), Pied Oystercatcher (*Haematopus longirostris*), Sooty Oystercatcher (*Haematopus fuliginosus*), Ruddy Turnstone (*Arenaria interpres*), and Whimbrel *(Numenius phaeopus*). Potential impacts on water quality within the area used to forage, has the potential to result in reduced foraging success from elevated levels of turbidity (Lunt and Smee 2015). However, such impacts are expected to be very short-term and localised (30 deposition days per year at Fingal and 20 at Dreamtime Beaches), thus potential impacts to foraging ability of the shorebirds are likely to be minimal

Should the proposed action result in significant changes to the geomorphology of the beach, there is also potential for impact on foraging habitat. The deposition of sand in shallow offshore areas is expected to provide some beach nourishment as it is predominately transferred to the north (Jacobs 2017), however any changes to natural extent and width of the beach are expected to be minimal. Furthermore, the majority of shorebirds that occur in the locality, typically utilise more sheltered habitats within the estuary for foraging at low tide.

Noise disturbances may also impact on birds roosting, nesting or breeding. There is potential that some species of shorebirds including the Beach Stone-curlew, Pied Oystercatcher and Sooty Oystercatcher may also breed along the shoreline or nearby on Cook Island. The majority of records of roosting shorebirds are restricted to nearby habitats adjacent to the Tweed River estuary (Figure 7), which are not expected to be

impacted by the actions considered in this assessment. There are however records of the Sooty Oystercatcher breeding on Cook Island (Figure 7). For the majority of migratory shorebird species, breeding does not occur on the Australian mainland. Impacts on threatened shorebirds that are known or have a high likelihood of occurring within the study area have been considered further through a five-part test and the impact assessment criteria (Appendix 2).

Like shorebirds, the proposed action has the potential to impact on foraging habitat of seabirds that occur in the area. Threatened seabirds that forage aerially and that may occur within the proposal area include the Eastern Osprey (*Pandion cristatus*), Flesh-footed Shearwater (*Puffinus carneipes*), Little Tern (*Sternula albifrons*), and White-bellied Sea-eagle (*Haliaeetus leucogaster*). Potential impacts on water quality within the area used to forage, has the potential to result in reduced foraging success from elevated levels of turbidity (Lunt and Smee 2015), or due to a reduction in prey species, which may avoid the area, as a result of elevated levels of suspended solids. For the majority of seabirds such impacts will likely be short-term, very localised, and only impact on a very small proportion of foraging grounds they access. However, for breeding and nesting species their ability to access more widespread foraging grounds may be limited. Species of seabirds known to nest on Cook Island, such as the Crested Tern and Wedge-tailed Shearwater (September to December), as well as the Silver Gull, which may nest nearby, and potential nesting habitat for Little Terns on Fingal Beach, are at greater risk to potential impacts on habitat quality of foraging grounds. The Crested Tern typically breeds in south-eastern Australia between September to January, while the Wedge-tailed Shearwater breeds along the New South Wales East Coast between August and December (DoE 2019b). The Little Tern nests along beaches in northern NSW, and potential nesting habitat may occur at Fingal Head, however records of nesting pairs at this site pre-date 1980 (NSW NPWS 2003). In addition, noise disturbance during sand deposition, albeit minimal also has greater potential to impact on these species that breed in habitats adjacent to the deposition sites. Increased vessel operations and noise, especially in close proximity to breeding seabirds has potential to disturb seabirds. These species are likely to be most vulnerable to noise disturbances during breeding season. It is expected that the potential noise disturbance will be minimal, given that breeding occurs above the tidal limits, and buffer is provided by the aquatic reserve boundary (for Cook Island) and the restriction to subtidal areas in 3 m or more depth (along the beach). The breeding season Impacts on threatened seabirds (this excludes the Silver Gull as marine species are not considered matters of national Significance under the EPBC Act) that are known or have a high likelihood of occurring have been considered further through a five-part test and the impact assessment criteria (Appendix 2).

Fish

The Black Rockcod (*Epinephelus daemelii*) is listed as vulnerable under both the FM Act and EPBC Act. Black Rockcod are large, reef-dwelling species that utilise caves, gutters and beneath bommies on rocky reefs (DPI 2015). They are also known to occur in the Cook Island Aquatic Reserve, and subsequently may at times utilise habitat in the proposal footprint to forage. Impacts on the Black Rockcod are likely restricted to small areas of potential foraging habitat only. However, potential impacts to this species have been considered further through a seven-part test and the impact assessment criteria (Appendix 2).

Sharks and Rays

The Grey Nurse Shark (*Carcharius taurus*) is listed as critically endangered under the FM act and endangered under the EPBC Act. Grey Nurse Sharks are found around shallow inshore reef areas with gravel or sand filled gutters, overhangs or caves (DPI 2013). They are also known to occur in the Cook Island Aquatic Reserve, and subsequently may at times utilise habitat in the proposal area to forage. Impacts on the Grey Nurse Shark are likely restricted to small areas of potential foraging habitat only. However,

potential impacts to this species have been considered further through a seven-part test and impact assessment criteria (Appendix 2).

Other sharks and rays that may occur in the proposal area include the Great White Shark (*Carcharodon carcharis*), which is listed as vulnerable under both the FM Act and EPBC Act. This species forages over the length of east coast of NSW that includes coastal and offshore areas. The proposal area is likely to constitute a very small and insignificant area of potential foraging habitat for this species. Impacts on Great White Sharks from the proposal are unlikely and not considered further.

Marine Mammals

The Humpback Whale (*Megaptera novaeangliae*) is listed as vulnerable under both the BC Act and EPBC Act. The Humpback whale migrates up the Australia East Coast annually, and at times utilises areas along the NSW and Southern QLD coast to rest. This species is likely to be seen migrating through the proposal area during the migration periods between March and October. At times Humpback Whales have been known to take refugee close to shore during their migration and on occasions calve before reaching there more recognised tropical breeding grounds. Interactions with vessels can impact on Humpback Whales during their migration or use of this habitat for refugee. Such interactions may include vessel strike and disturbance while taking refuge and resting, particularly when with calves. Impacts on the Humpback Whale have been considered further through a five-part test and the significant impact assessment criteria (Appendix 2).

Turtles

The Green Turtle (*Chelonia mydas*), listed as vulnerable under both the BC Act and EPBC Act, Loggerhead Turtle (*Caretta caretta*), listed as endangered under the BC and EPBC Acts, and the Hawkesbill Turtle, (*Eretmochelys imbricate*) listed as vulnerable under the EPBC Act, may occur in the proposal area. The Green and Loggerhead turtles are known to occur in the Cook Island Aquatic Reserve (Cuttriss 2014) and on occasions some individuals will nest on the adjacent beaches (FRC Environmental 2017a), with nesting likely to occur within the southern Queensland nesting season between October and March (Limpus, 2008a, 200b), however turtles may nest in the Tweed area as late as May (Hydrosphere Consulting 2017) and does not typically commence before November. Searches of the NSW Office of Environment and Heritage BioNet database detected a record of nesting Loggerhead Turtle, approximately 300 m south of the Dreamtime deposition area (Figure 8). All three-turtle species have been recorded in the locality and are likely to feed around the reefs within the Aquatic Reserve and travel through the proposal area. Recent research on the movements of turtles around Cook Island found turtles will regularly move two to three km from the reef at Cook Island (Cuttriss 2014). Possible interactions between vessels and sea turtles have potential to also impact on sea turtles in the study area. Underwater noise and vessel usage in close proximity may result in vessel strikes, which can have fatal impacts for individual turtles. Noise and vessel interactions also has potential to disturb any nesting turtles, while changes to the geomorphology of the adjacent beach may impact on nesting success. The potential to disturb nesting turtles will be minimal as such events are typically isolated and scattered occurrences rather than large scale nesting events, while vessel movements will be restricted to approximately 125 movements per annum. Impacts on the geomorphology of the beach are expected to be minimal in comparison with naturally occurring sediment transport processes and would not result in any major changes to the adjacent beach (See Jacobs 2017). Impacts on turtles have been considered further through a five-part test and the impact assessment criteria (Appendix 2).

5.8.7 Migratory and marine species

Birds

In addition to the threatened species, another 15 species of listed migratory and marine birds may occur in proposal area (Table 3). Migratory shorebirds are most likely to visit the area between September and April (Hydrosphere Consulting 2017). Migratory birds are protected by various bilateral international agreements (e.g. CAMBA, JAMBA, ROKAMBA) and are considered a matter of national environmental significance (MNES) under the EPBC Act. Potential foraging habitat for migratory and marine seabirds that forage aerially is present for Fork-tailed Swift (*Apus pacificus*), Wedge-tailed Shearwater (*Ardenna pacifica*), Crested Tern (*Thalasseus bergii*), Silver Gull (*Chroicacephalus novaehollandiae*), as well as numerous other species. The Wedge-tailed Shearwater and Crested Tern are known to breed on Cook island, and Silver Gull nearby. Thus, the proposal has potential to impact on both feeding and adjacent breeding habitat of seabirds. Impacts on migratory seabirds have been considered further through a five-part test and the impact assessment criteria (Appendix 2).

Marine Mammals

The Spotted Bottlenose (*Tursiops aduncus*), and Bottlenose (*Tursiops truncatus*) Dolphins listed as Marine under the EPBC Act are likely to occur within the proposal area. Underwater noise and interactions with dredging vessels may result in vessel strikes and have potential to impact dolphins that are foraging in or traveling through the study area. Impacts on dolphins have been considered further through the impact assessment criteria (Appendix 2).

5.8.8 Other fauna

Fish

The protected Giant Queensland Groper (*E. lanceolatus*) and Estuary Cod (*E. coioidesi)* may utilise refuge amongst reefs within the Cook Island Aquatic Reserve. At times these species may forage across sandy sediments adjacent to the reef that may include the proposal area. However, utilisation of foraging habitat in the proposal area is likely to be minimal and unlikely to impact on any individuals residing in the nearby aquatic reserve.

Any impacts on water quality may indirectly impact on reef and pelagic fish, which utilise habitat in the proposal area and adjacent reefs. Pelagic fish will likely avoid the area when water quality conditions area not optimal. Potential impacts on pelagic fish are likely to be minimal as the proposal area represents only a very small part of the coastline they may utilise. Many reef species on adjacent reefs will have likely recruited to the reef system, and as such may not be able to avoid impacts on water quality that impinge on nearby reefs. However, the potential for impacts on reef fish from diminished water quality in this proposal remains low due to the material being clean marine sand, which will minimise pluming of the sediments when deposited (DSITI 2016).

Corals

The reefs within the adjacent Cook Island Aquatic Reserve include a healthy cover of corals (FRC 2017). Corals are very sensitive to impacts from sedimentation and turbidity as many rely on photosynthesis by their symbiont algae. Sedimentation can result in decreased coral diversity, less live coral cover, lower coral growth rates, greater abundance of branching forms, reduced coral recruitment, decreased calcification, decreased net productivity of corals, and slower rates of reef accretion (Rogers 1990). While potential for impacts on reef fish from diminished water quality in this proposal remains low due to the sandy nature of the sand (DSITI 2016), the magnitude of impacts of sedimentation and poor water quality on corals remain high. In this area sediment modelling indicates a very dynamic sediment transport system, resulting in temporally very variable patterns of sediment movement and deposition around Cook Island and Fingal

Head (Jacobs 2017). Given this, it is likely that reef communities around Cook Island are comprised of a greater abundance of species more tolerant to sediment deposition that other nearby reefs.

6. Recommendations

The proposal has the potential to impact directly on soft sediment communities within the proposal area may result in changes to the infauna assemblage. The potential impacts on sediment quality are considered low for this proposal, however any impacts on water quality has potential to impact on fauna, such as shorebirds and seabirds and predatory fish, mammals and sharks that utilise the proposal area to forage; and flora and fauna, such as corals and macroalgae on adjacent reefs inside the aquatic reserve. Noise and vessel operation associated with the proposal also has the potential to result in disturbance of cetaceans and birds, especially birds that may be breeding nearby, and vessel strikes on cetaceans and turtles.

The potential for waste, spills, and debris and introduction of noxious species to impact on aquatic flora and fauna will be managed through implementation of a detailed Construction Environmental Management Plan for the project.

As a general principle and as a first priority, it is recommended to aim to avoid impacts. Where avoidance is impossible or impractical, impacts should be minimised and/or mitigated. Any remaining impacts should then be offset with compensatory works (Fairfull 2013). Following this approach our recommendations are outlined below.

6.1 Benthic habitats

Impacts on soft sediment communities can be minimised by allowing these communities to recover, by alternating the locations of spoil deposition and maintaining sediment volumes well within the natural capacity of the system. This will minimise long-term changes amongst the infauna community, which typically recover after 24 months.

Reef habitats are outside the proposal area, however any effects on water quality have the potential to impact these nearby habitats, which include the Cook Island Aquatic Reserve and hard coral assemblages. Where water quality impacts and sedimentation impacts are detected amongst adjacent reefs within the Aquatic Reserve, further assessment and monitoring of reef assemblage should be implemented.

The existing monitoring program of Kirra Reef Biota for the Tweed Sand Bypassing project, which recently utilised Cook Island sites as potential controls (FRC 2017a), could be continued to meet monitoring requirements of this proposal. Monitoring variables should include a mix of both biotic and abiotic variables. Biotic variables should include reef assemblage composition, as well as percent cover for live hard coral, macroalgae and sediment. Abiotic variables should include reef sediment deposition, TSS and secchi depth (water clarity). Given that sediment movement in the area is naturally high and temporally very variable, a thorough baseline data set that includes multiple surveys is recommended to ensure temporal variation is adequately accounted for in the development of baseline condition of the reef, sediment deposition and water clarity. For TSS the development of a site-specific trigger value is optimal, however where sufficient data is not available adoption of ANZECC water quality guidelines values would be sufficient. In the Kirra Reef Biota Monitoring, one of the limitations of the monitoring program has been identifying suitable control sites (FRC 2017a). Likewise, comparable control sites for monitoring at Cook Island may also not be possible. Given this, the collection of sufficient baseline data will be critical to the success of the monitoring program and its ability to distinguish between changes from the proposed action and those that occur naturally.

Recommendations to minimise and manage impacts on benthic habitats include:

- Avoid repeated deposition of spoil in one area to minimise potential for continuous impacts.
- Consideration of the rotation of deposition areas to allow benthic soft bottom communities to recover post-deposition.
- Adopt and adapt the Kirra Reef Biota Monitoring Program to include Cook Island. This should include inclusion of abiotic variables and collection of sufficient baseline dataset to account for temporal variability.

6.2 Sediment and water quality

There is minimal potential for impacts on sediment quality from this proposal as the sands to be dredged for the beach nourishment are bare sands. However, flood events and or major storms have potential to change the sediment composition of the bar to be dredged. Sediments outside the dredge area have also not been assessed for contaminants since 1997. Water quality parameters such as turbidity and sedimentation have the potential to impact on fauna, flora, the Aquatic Reserve, and adjacent reef communities, which include hard corals. Where increased risks of exposure of reef habitats within the aquatic reserve to elevated levels of suspended solids are expected or detected, monitoring for sedimentation and impacts to reef flora and fauna should be considered.

Recommendations to avoid, minimise and manage impacts on sediment and water quality include:

- Assessment of sediment contamination in accordance with the National Assessment and Guidelines for Dredging 2009 (DEWHA2009) if there are any changes to the dredge area or potential for/ suspected change in sediment quality /attributes from the proposed dredge area.
- Regular testing of waters within the Aquatic Reserve for TSS during deposition of sediments should be considered as part of the Environment protection licence (EPL) for the dredging works.
- Deposition of sediments with contaminants or substantially different characteristics to the those that naturally occur at the deposition site should be avoided.

6.3 Waste, spills and debris, and introduced and noxious species

There is minimal potential for or increased risks from wastes, spills and debris from the proposal. Likewise, the proposal has minimal risks of the introduction of introduced and/ or noxious species to the study area. However, thorough management of construction works is required to minimise and mitigate these potential risks.

Recommendations to minimise and manage potential impacts from waste, spills and debris include the following practises during construction:

- Regular inspection and maintenance of equipment, fuel holds, hydraulic lines etc. of construction equipment and vessels.
- Spill kits to be on hand and all petroleum products and chemical products to be stored in a bunded area.
- Suitable rubbish bins to be provided for rubbish disposal on all vessels.
- No disposal of materials (other than sediment) overboard.
- Cleaning of all equipment before being taken into the proposal area.
- Inspection of all equipment that has been mobilised from states other than NSW/QLD for introduced and noxious species.

6.4 Fauna and flora

Numerous species of seabirds including numerous threatened and migratory species may utilise habitat within the proposal area to forage. Where seabirds are feeding at the time of sand placement, a sufficient distance should be maintained to avoid impacting seabirds utilising foraging habitat. Furthermore,

numerous species may breed and nest in the vicinity of the proposal. The Aquatic Reserve around Cook Island provides buffer for birds breeding and nesting on the Island. Should any birds or turtles be breeding or nesting along the shoreline, the area should be avoided, and sufficient distance should be maintained.

Reef fish and sharks, as well as dolphins are likely to be in most cases transient and at times may forage within the proposal area. Thus, there is minimal potential from the proposal to impact on foraging behaviour and success of these species.

Turtles, dolphins and whales spend time on the water surface, and subsequently can be at higher risk to vessel strike then other marine fauna. These impacts can be managed through implementation of standard practises that adhere to operating procedures around marine mammals outlined in the *NSW Biodiversity Conservation regulation 2017*.

Recommendations to minimise and manage potential impacts from waste, spills and debris include the following practises during construction:

- Avoid deposition of spoil in areas where seabirds or shorebirds (in adjacent intertidal areas at low tide) are foraging.
- Consult with local NPWS Office to avoid occurrences of nesting birds and turtles and minimise works in close proximity to Cook Island during breeding season.

Recommendations to minimise impacts on marine fauna have been adopted from the NPWS guideline for approaching marine mammals, which has been adopted from the National Guideline (DEE 2017). These include:

- Maintaining a distance of 300 m from any whales, dolphins or dugongs.
- Maintaining a distance of 80 m from any sealions or seals.

In addition, it is recommended theses approach distances be extended to

- Breeding/ nesting shorebirds and sea turtles – 300 m. (Local NPWS should advise operators of such occurrences)
- Foraging shorebirds and sea turtles – 80 m.

7. Conclusions

Impacted habitat will be confined to soft sediment communities, which naturally have high and very variable patterns in sediment movement and deposition. Impacts on fauna include potential to impact on foraging habitat quality, potential for disturbance of breeding/nesting individuals through noise and increased risk of vessel strike.

The proposal is adjacent to the Cook Island Nature Reserve and in close proximity to the Cook Island Aquatic Reserve. The Cook Island Nature Reserve includes a number of threatened and migratory species with both state and Commonwealth significance, some of which breed on the Island. Thus, measures to avoid, minimise or mitigate potential for impacts on the Cook island Nature Reserve should be considered carefully as part of this proposal.

The proposal is considered unlikely to have a significant impact on State and/or Commonwealth listed threatened biodiversity, or MNES. Referral to the Department of the Environment under the EPBC Act is not required. Similarly, the preparation of a species impact statement (SIS) based on the provisions of the BC or FM Act is not required.

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Figures

Project Area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

FIGURE 1

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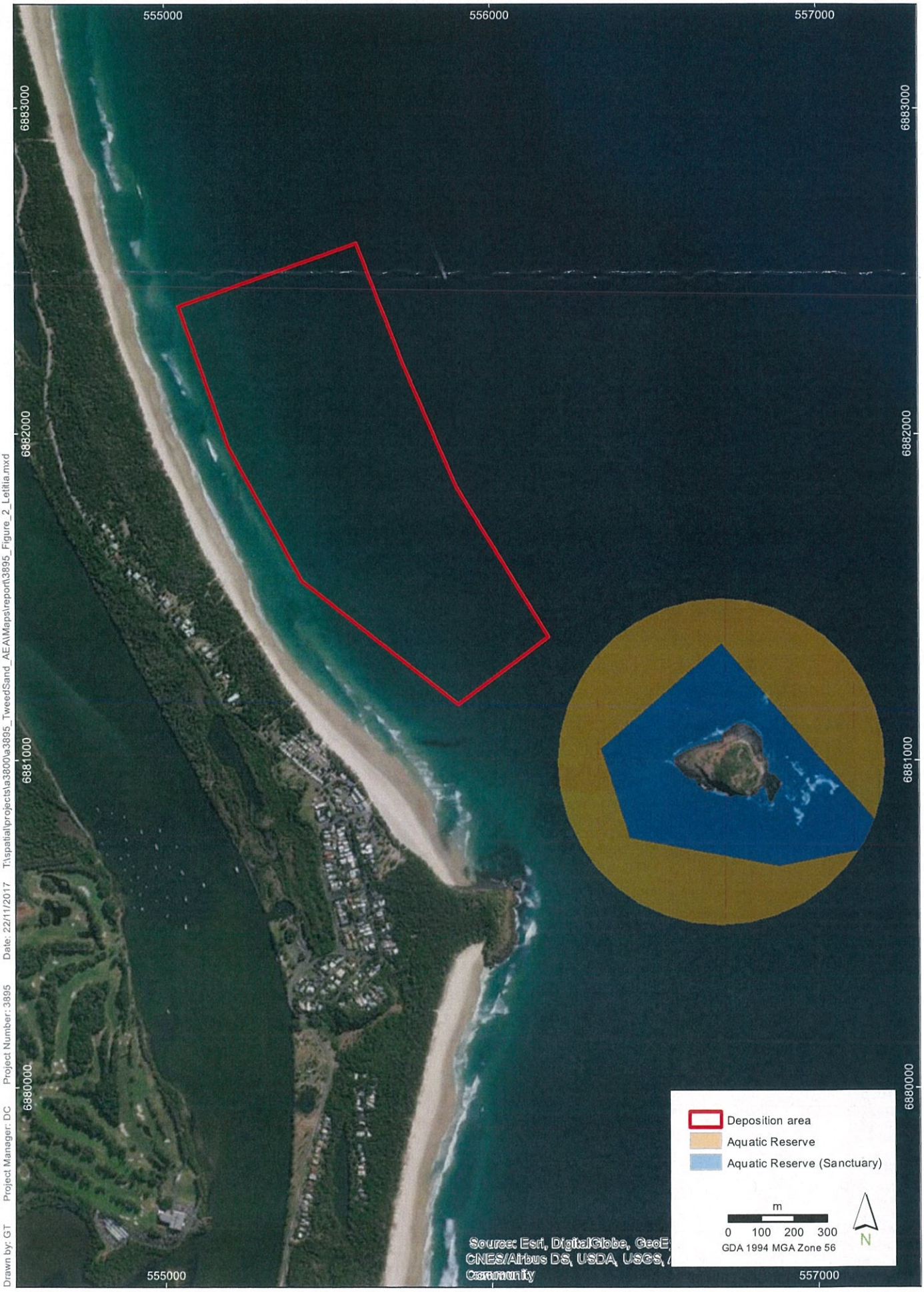

Fingal sand backpass area

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FIGURE 2

Imagery: (c) DigitalGlobe 2016-01-06

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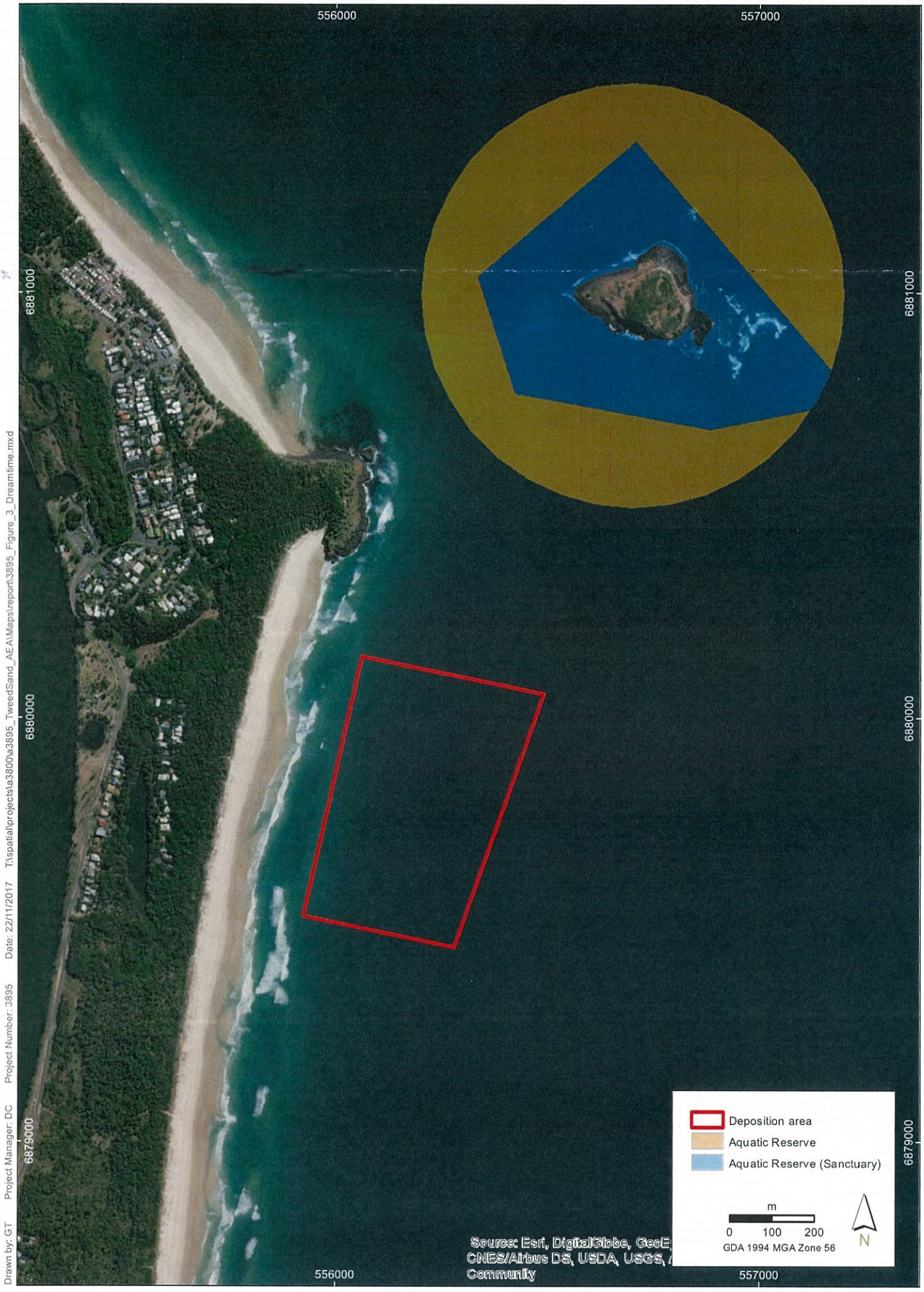

Dreamtime sand backpass area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

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FIGURE 3

Imagery: (c) DigitalGlobe 2016-01-06

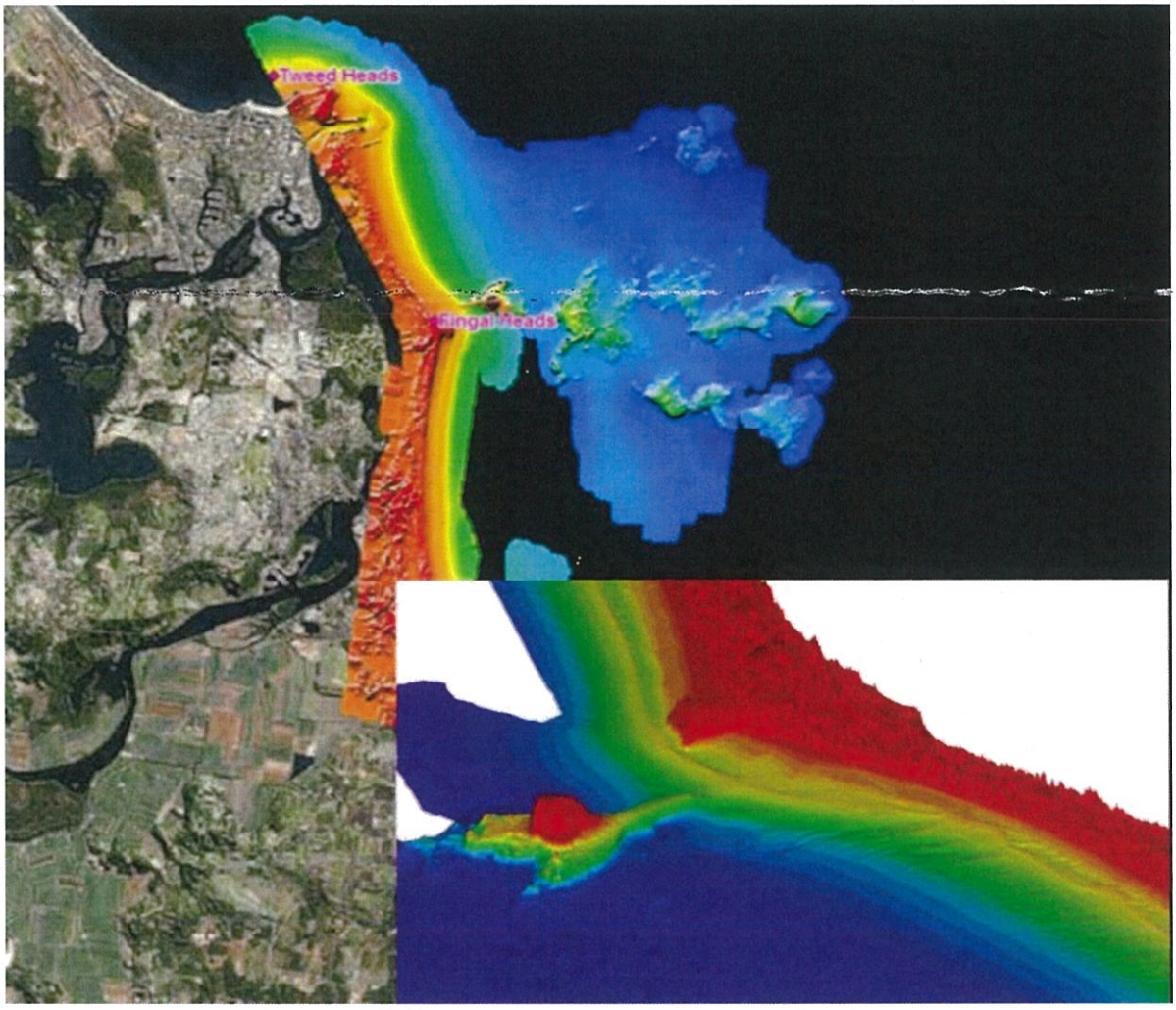


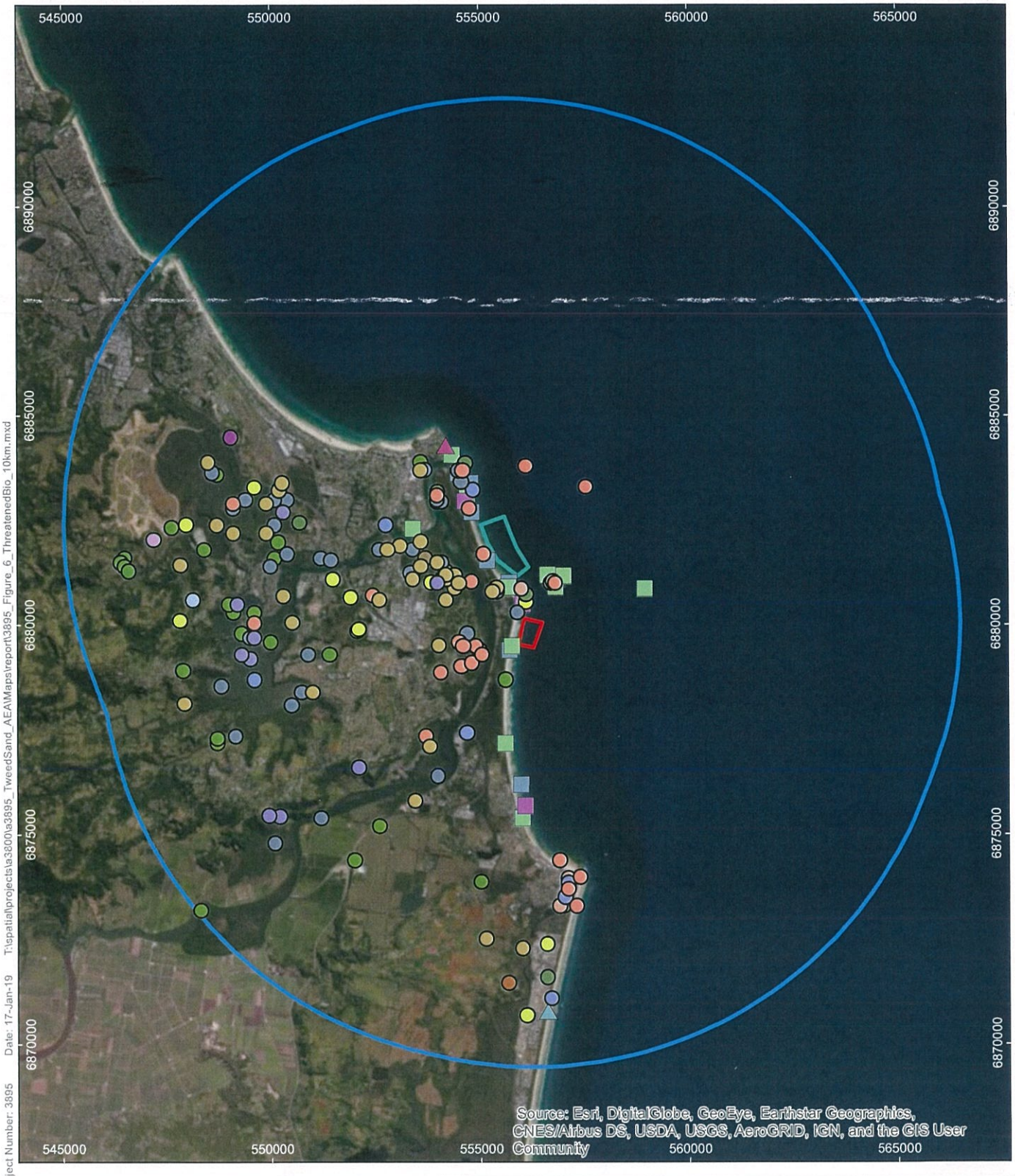
Figure 4: LIDAR mapping of the Tweed and Fingal Head coast

Source: data supplied by DOI LANDS 2017

Insert: Detailed LIDAR imagery from around Fingal Head.

Figure 5: Review of Aerial Imagery showing shallow reef areas (Source Nearmap).

- Black circles indicate areas of permanent reef habitat associated with Cook Island
- Red circles indicate areas of potential rocky substrate that may cover with sand associated with Southern Fingal Head



Reptiles
- Green Turtle
- Hawksbill Turtle
- Loggerhead Turtle

Mammals
- Australian Fur-seal
- Humpback Whale

Birds
- Beach Stone-curlew
- Black Bittern
- Black-necked Stork
- Black-tailed Godwit
- Collared Kingfisher
- Comb-crested Jacana
- Curlew Sandpiper
- Eastern Curlew
- Flesh-footed Shearwater
- Great Knot
- Greater Sand-plover
- Lesser Sand-plover
- Little Tern
- Northern Giant-Petrel
- Pied Oystercatcher
- Red Knot
- Sooty Oystercatcher
- Terek Sandpiper
- Wandering Albatross
- White-bellied Sea-Eagle
- White-eared Monarch

- Letitia
- 10km search area
- Dreamtime

km
0 1 2
GDA 1994 MGA Zone 56
N

Drawn by: MH Project Manager: DC Project Number: 3895 Date: 17-Jan-19 T:\spatial\projects\a3800\a3895_TweedSand_AEA\Maps\report\3895_Figure_6_ThreatenedBio_10km.mxd

Threatened biodiversity records within 10 km of the study area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

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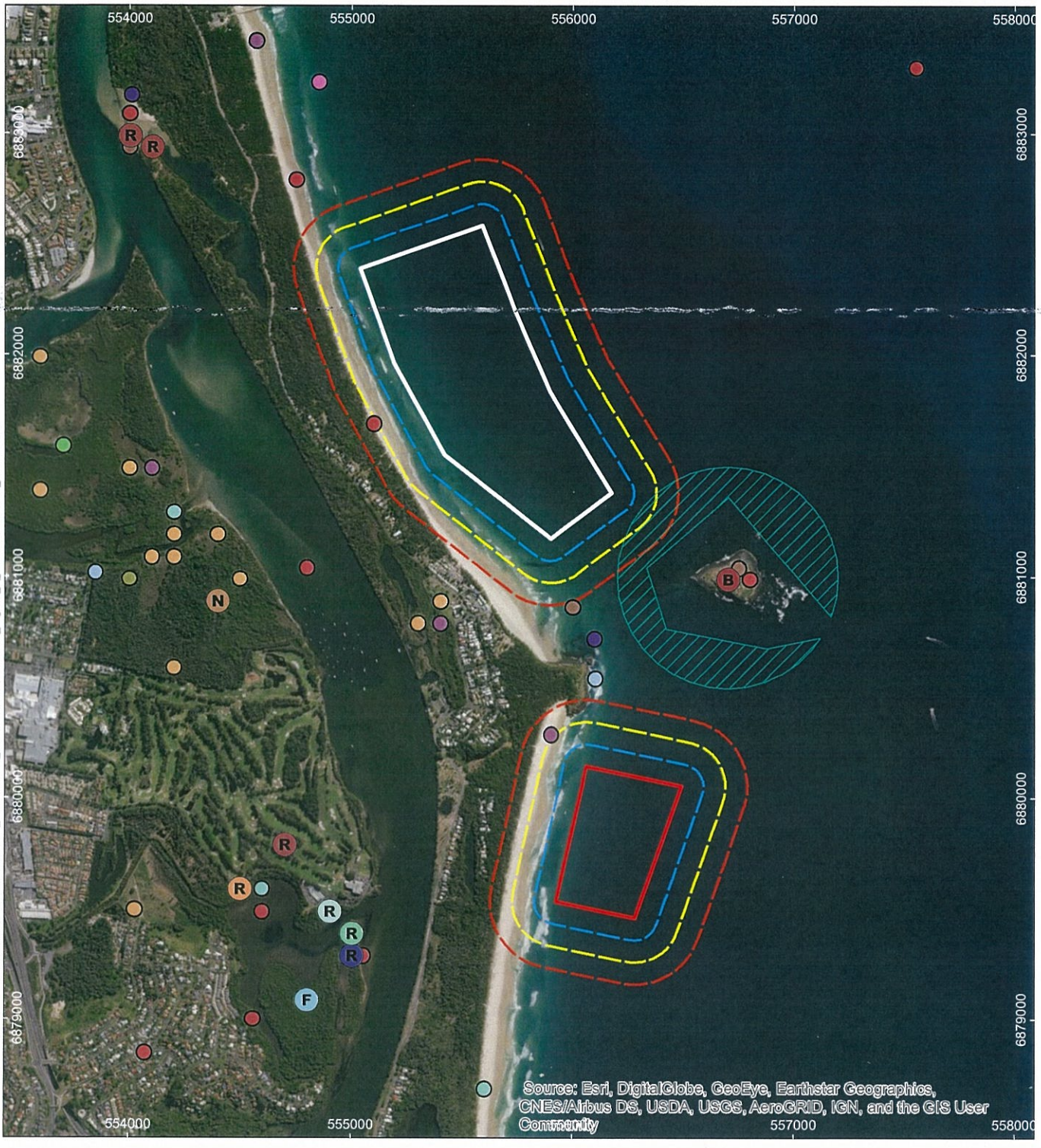
FIGURE 6

Data obtained from NSW Office of Environment and Heritage's BioNet Atlas, which holds data from a number of custodians. Data obtained 14/01/2019



Drawn by: MH Project Manager: DC Project Number: 3895 Date: 17-Jan-19 T:\spatial\projects\a3800\a3895_TweedSand_AEA\Maps\report\3895_Figure_7_ThreatenedBirds_500m.mxd

Birds
- Beach Stone-curlew
- Black Bittern
- Black-necked Stork
- Black-tailed Godwit
- Collared Kingfisher
- Curlew Sandpiper
- Eastern Curlew
- Flesh-footed Shearwater
- Great Knot
- Greater Sand-plover
- Little Tern
- Pied Oystercatcher
- Red Knot
- Sooty Oystercatcher
- Terek Sandpiper
- White-bellied Sea-Eagle
- White-eared Monarch

Roosting
- Black-tailed Godwit
- Curlew Sandpiper
- Eastern Curlew
- Great Knot
- Greater Sand-plover
- Lesser Sand-plover
- Little Tern
- Pied Oystercatcher
- Red Knot
- Sooty Oystercatcher
- Terek Sandpiper

Nesting
- Collared Kingfisher

Breeding
- Sooty Oystercatcher

Feeding
- Curlew Sandpiper
- Eastern Curlew
- Great Knot
- Greater Sand-plover
- Lesser Sand-plover
- Little Tern
- Dreamtime

Letitia
- Cook Island Aquatic Reserve
- 100m radius from deposition area
- 200m radius from deposition area
- 300m radius from deposition area

m
0 250 500
GDA 1994 MGA Zone 56
N

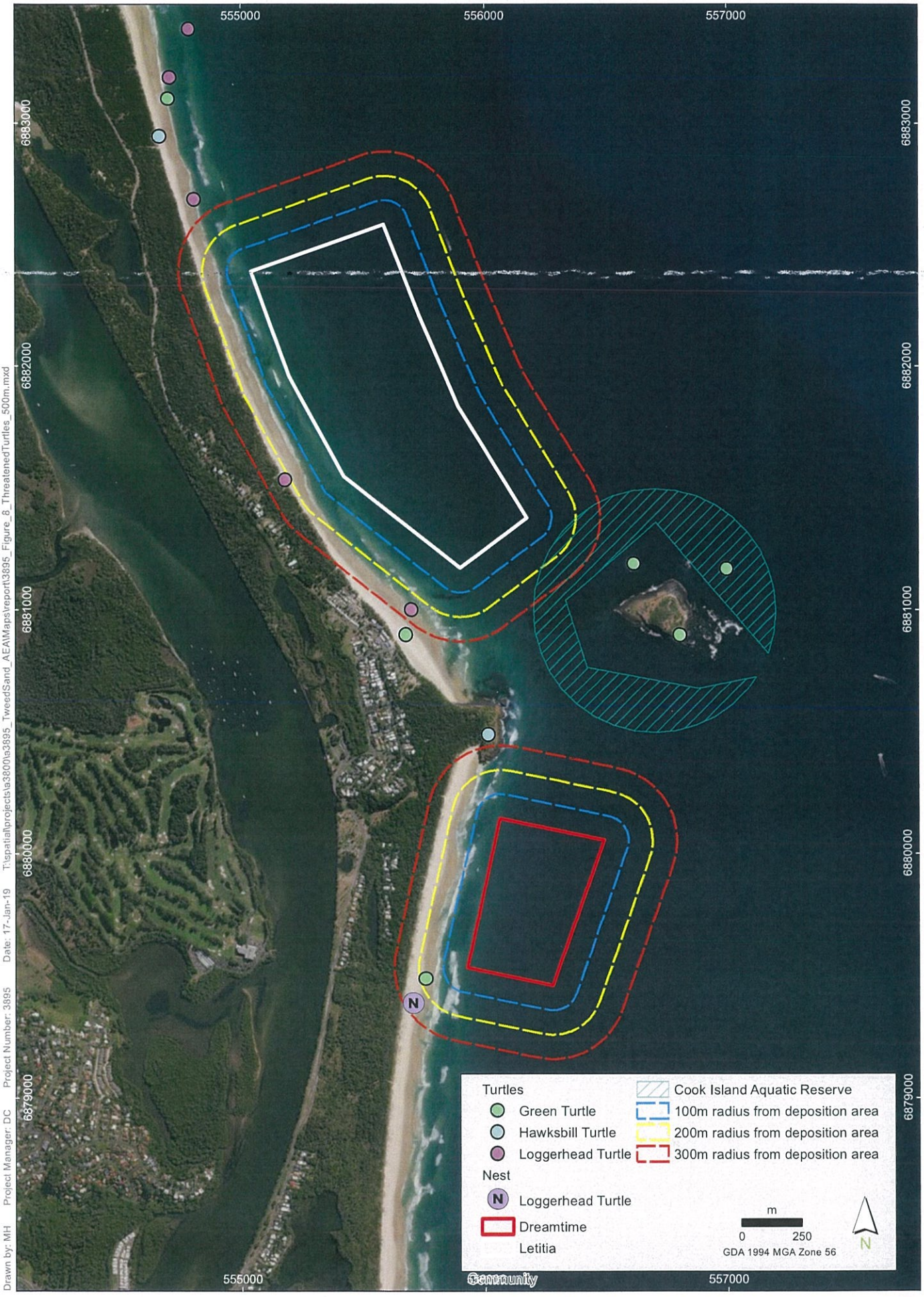
Threatened birds recorded within the study area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

niche Environment and Heritage

FIGURE 7

Data obtained from NSW Office of Environment and Heritage's BioNet Atlas, which holds data from a number of custodians. Data obtained 14/01/2019



Threatened turtles recorded within the study area

Tweed Sand Backpassing - Aquatic Ecology Assessment Update

FIGURE 8

Data obtained from NSW Office of Environment and Heritage's BioNet Atlas, which holds data from a number of custodians. Data obtained 14/01/2019

Appendices

Appendix 1 – Threatened aquatic species, populations and ecological communities likelihood of occurrence

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Communities/ Populations (Estuarine only)							
	Subtropical and Temperate Coastal Saltmarsh	E	V		Occurs in the intertidal zone on the shores of estuaries and lagoons including when they are intermittently closed along the NSW coast. Coastal saltmarsh has been recorded from sites along the NSW coast. (NSW North Coast, Sydney Basin and South East Corner Bioregions).	None -- no suitable habitat	No
Birds							
Diomedea antipodensis	Antipodean Albatross	V	V, M, MA		Mainly inhabits coniferous, deciduous and mixed forests. Breeds in northern hemisphere. Brood parasite, laying eggs in nests of other birds.	Low – Possible transient visitor	Low
Botaurus poiciloptilus	Australasian Bittern	E	E		The Australasian Bittern is widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes and spikerushes.	None -- no suitable habitat	No
Rostratula australis	Australian Painted Snipe	E	E, MA		In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	Low – Possible transient visitor	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Limosa lapponica baueri	Bar-tailed Godwit	-	M, V		Bar-tailed Godwit (spp *baueri*) is the eastern Australian / New Zealand sub species. Mainly found in coastal habitats such as intertidal sand flats, mudflats, estuaries, inlets, coastal lagoons and bays. Often found around beds of seagrass and saltmarsh. Northern hemisphere breeding.	Low – lack of suitable foraging habitat	Unlikely
Esacus neglectus	Beach Stone Curlew	CE	MA		Occupies coastlines from about Point Cloates in Western Australia, across northern and north-eastern Australia south to north-eastern NSW, with occasional vagrants to south-eastern NSW and Victoria. In NSW, the species occurs regularly to about the Manning River, and the small population of north-eastern NSW is at the limit of the normal range of the species in Australia.	Known	Possible
Ixobrychus flavicollis	Black Bittern	V	-		Usually found on coastal plains below 200 m. Often found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterized by dense waterside vegetation.	None – no suitable habitat	No
Turnix melanogaster	Black-breasted Button-quail	CE	V		The Black-breasted Button-quail is endemic to south-eastern Queensland and far north-eastern NSW, at scattered sites from the Byfield region south to the Border Ranges and mainly on and east of the Great Divide but extending inland to the inner western slopes, up to 300 km from the coast. Preferred habitat is drier low closed forests, including dry rainforests, vine forest and vine thickets, often in association with hoop pine, and bottletree scrubs.	None – no suitable habitat	No
Thalassarche melanophris	Black-browed Albatross	V	V, M, MA		The Black-browed Albatross has a circumpolar range over the southern oceans and are seen off the southern Australian coast mainly during winter.	Low – Possible transient visitor	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					Inhabits Antarctic, subantarctic, subtropical marine and coastal waters over upwellings and boundaries of currents.		
Monarcha melanopsis	Black-faced Monarch	-	M		Found along the coast of eastern Australia, becoming less common further south. Inhabits rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating.	None -- no suitable habitat	No
Ephippiorhynchus asiaticus	Black-necked Stork	E	-		Mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sand flats, and mangrove vegetation.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Limosa limosa	Black-tailed Godwit	V	M		Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sand flats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps. Northern hemisphere breeding.	Moderate – marginal foraging habitat	Unlikely
Burhinus grallarius	Bush Stone-curlew	E	-		The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east, it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy ground layer and	Moderate – marginal foraging habitat	Possible

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					fallen timber. Largely nocturnal, being especially active on moonlit nights.		
Ardea ibis	Cattle Egret	-	M		The Cattle Egret is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor.	Low – lack of suitable habitat	Unlikely
Todiramphus chloris	Collared Kingfisher	V	-		In NSW, the species is observed regularly only at Ukerebagh and nearby Cobaki Broadwater, and it breeds along the Tweed River estuary. Collared Kingfishers are virtually restricted to mangrove associations of estuaries, inlets, sheltered bays and islands, and the tidal flats and littoral zone bordering mangroves. They sometimes occur in terrestrial forests or woodlands bordering mangroves and are sometimes see in streets or gardens in built-up areas bordering mangrove vegetation.	Low - species known to breed in Tweed River estuary but study site does not provide suitable habitat	Unlikely
Irediparra gallinacea	Comb-crested Jacana	V	-		Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Low – lack of suitable habitat	Unlikely
Tringa nebularia	Common Greenshank	-	M		Variety of inland wetlands and sheltered coastal habitats of varying salinity. Found on mudflats, saltmarsh, mangroves in embayments, harbours, deltas and lagoons. Breeds in northern hemisphere.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Actitis hypoleucos	Common Sandpiper	-	M, MA		Utilises a wide range of coastal wetlands and some inland wetlands, mostly found around muddy margins or rocky shores. Forages in shallow water and on soft mud, roosts on rocks or vegetation such as mangroves. Northern hemisphere breeding.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Calidris ferruginea	Curlew Sandpiper	E	CE, M		It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater	Moderate – marginal foraging habitat and	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland. Northern hemisphere breeding.	sightings restricted to inside the estuary	
Charadrius bicinctus	Double-banded Plover	-	M		Found on littoral, estuarine and fresh or saline terrestrial wetlands, rocky beaches, bays and inlets. Sometimes found on exposed reefs and rock platforms. Migrates to breed in New Zealand.	High – Minimal foraging habitat	Unlikely
Numenius madagascariensis	Eastern Curlew	-	CE, MA, M		A primarily coastal distribution. Found in all states, particularly the north, east, and south-east regions including Tasmania. Rarely recorded inland. Mainly forages on soft sheltered intertidal sand flats or mudflats, open and without vegetation or cover. Breeds in the northern hemisphere.	High – Minimal foraging habitat	Unlikely
Pandion cristatus, Pandion haliaetus	Eastern Osprey	V	M, MA		Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water.	High –foraging habitat	Foraging habitat will likely occur within the study area
Puffinus carneipes Ardenna carneipes	Flesh-footed Shearwater	V	-		The Flesh-footed Shearwater mainly occurs in the subtropics over continental shelves and slopes and occasionally inshore waters	High –foraging habitat	Foraging habitat will likely occur within the study area

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Apus pacificus	Fork-tailed Swift	-	M		The Fork-tailed Swift is almost exclusively aerial, flying from less than one metre to at least 300 m above ground and probably much higher.	Moderate – potential foraging habitat	Possible
Diomedea gibsoni, Diomedea antipodensis gibsoni	Gibson's Albatross	V	V, M, MA		The species is regularly encountered on trans-Tasman shipping routes and at seas off Sydney, and regularly occurs off the NSW coast usually between Green Cape and Newcastle. This species is known only to breed on the Adams, Disappointment and Auckland Islands in the subantarctic Auckland Island group. Potential forage in NSW waters during the winter is considered significant for the species.	Low – Possible transient visitor	Unlikely
Ardea alba	Great Egret	-	M		Great Egrets prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Calidris tenuirostris	Great Knot	V	M, CE		In NSW, this species has been recorded at scattered sites along the coast to about Narooma. It has also been observed inland at Tullakool, Armidale, Gilgandra and Griffith. Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sand flats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and islets and sometimes on exposed reefs or rock platforms. Northern hemisphere breeding.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Charadrius leschenaultii	Greater Sand Plover	V	M, V		Occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons. Non-breeding in Australia.	Moderate – marginal foraging habitat	Unlikely
Pluvialis squatarola	Grey Plover	-	M		Almost entirely in coastal areas including sheltered embayment's, estuaries and lagoons with mudflats and sand flats, and occasionally on rocky coasts with	Low – No sightings and minimal habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					platforms or reef flats. Breeds in northern hemisphere.		
Tringa brevipes, Heteroscelus brevipes	Grey-tailed Tattler	-	M, MA		Found on sheltered coasts with reefs and rock platforms, intertidal mudflats, estuaries and coastal lagoons, especially fringed with mangroves. Northern hemisphere breeding.	Moderate – marginal foraging habitat	Unlikely
Pterodroma neglecta neglecta	Kermadec Petrel (west Pacific subspecies)	V	V		Typically nests on the surface in loose colonies among rocks and vegetation. On Ball's Pyramid it nests only on steep cliffs above 400 m. On Phillip I. it nests under stands of African Olive. This species is marine and highly pelagic, rarely approaching land except at colonies.	Low – No sightings and typically remains offshore	Unlikely
Gallinago hardwickii	Latham's Snipe	-	M		Latham's Snipe is a non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. Latham's Snipe breed in Japan and on the east Asian mainland. Seen in small groups or singly in freshwater wetlands on or near the coast, generally among dense cover. They are found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Charadrius mongolus	Lesser Sand Plover	V	M, E		Inhabits large intertidal sand flats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. Non-breeding in Australia.	Moderate – marginal foraging habitat and sightings restricted to inside the estuary	Unlikely
Numenius minutus	Little Curlew	-	M		Feeds in short, dry grassland and sedgeland, including dry floodplains and black soil plains, which	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					have scattered, shallow freshwater pools. Northern hemisphere breeding.		
Sternula albifrons	Little Tern	E	M		In Australia, Little Terns inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches.	Known	Possible
Calidris subminuta	Long-toed Stint	-	M		Prefers shallow freshwater or brackish wetlands including lakes, swamps, river floodplains and sewage ponds. Uncommon at tidal estuaries and salt ponds. Northern hemisphere breeding.	Low – No sightings and typically remains inland	Unlikely
Tringa stagnatilis	Marsh Sandpiper	-	M		Permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, sewage farms and salt works. Northern hemisphere breeding.	Low –Sightings restricted to upper estuary	Unlikely
Macronectes halli	Northern Giant Petrel	V	V		Breeding in Australian territory is limited to Macquarie Island and occurs during spring and summer.	Low – No sightings	Unlikely
Charadrius veredus	Oriental Plover	-	M		After arriving in non-breeding grounds in Australia, initially spends a few weeks in coastal habitats such as estuarine mudflats, sandy or rocky beaches, before dispersing further inland. Thereafter inhabits flat, open grasslands where the grass is short and sparse, interspersed with hard, bare ground such as claypans or dry paddocks. Northern hemisphere breeding.	Low – No sightings	Unlikely
Pluvialis fulva	Pacific Golden Plover	-	M		Coastal habitats such as beaches, mudflats, sand flats, estuaries, lagoons and evaporation ponds in salt works. Northern hemisphere breeding.	Moderate – marginal foraging habitat and	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
						sightings restricted to inside the estuary	
Calidris melanotos	Pectoral Sandpiper	-	M		Prefers shallow fresh to saline wetlands, found at coastal lagoons, estuaries, bays, swamps, inundated grasslands, saltmarshes and artificial wetlands. Northern hemisphere breeding.	Low – No sightings	Unlikely
Haematopus longirostris	Pied Oystercatcher	E	-		The Pied Oystercatcher inhabits marine littoral habitats, including islands. It occupies muddy, sandy, stony or rocky estuaries, inlets and beaches, particularly intertidal mudflats and sandbanks in large marine bays.	Known – marginal foraging habitat	Possible
Gallinago stenura	Pin-tailed Snipe	-	M		Occurs at edges of shallow freshwater swamps, ponds and lakes with emergent, sparse to dense cover of grass/sedge or other vegetation. Also found on more open wetlands, claypans and sewage ponds. Breeds in the northern hemisphere.	Low – lack of suitable habitat. No sightings	Unlikely
Erythrotriorchis radiatus	Red Goshawk	CE	V		Distributed sparsely through northern and eastern Australia, from the western Kimberley Division of northern Western Australia to north-eastern Queensland and south to far north-eastern NSW, and with scattered records in central Australia. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers. Very rare in NSW.	Low – No sightings	Unlikely
Calidris canutus	Red Knot	-	M, E		Usually found foraging in soft substrate near the edge of the water on intertidal mudflats. Also have been recorded at nearby lakes, sewage ponds and floodwaters. Roosts on sandy beaches, spits and islands. Northern hemisphere breeding.	Low – Few sightings and typically restricted to inside the estuary	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Calidris ruficollis	Red-necked Stint	-	M		Mostly found in coastal areas including inlets, bays, lagoons and estuaries with intertidal mudflats. Occasionally on exposed ocean beaches and sometimes rocky shores and reefs. Northern hemisphere breeding.	Low – Few sightings and typically restricted to inside the estuary	Unlikely
Arenaria interpres	Ruddy Turnstone	-	M		Mainly found in coastal regions with exposed rock coast lines or coral reefs. Also found on rock platforms with shallow tidal pools, and occasionally beaches and estuaries. Northern hemisphere breeding.	High – Some sightings around rocky coastline	Unlikely
Rhipidura rufifrons	Rufous Fantail	-	M		Found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Inhabits tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	Low – lack of suitable habitat	Unlikely
Calidris alba	Sanderling	V	M		Found in coastal areas on low beaches of firm sand, near reefs and inlets, along tidal mudflats and bare open coastal lagoons; individuals are rarely recorded in near-coastal wetlands. Northern hemisphere breeding.	Low – No sightings	Unlikely
Myiagra cyanoleuca	Satin Flycatcher	-	M		The Satin Flycatcher is found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	None – no suitable habitat	No
Calidris acuminata	Sharp-tailed Sandpiper	-	M		Prefers muddy edges of shallow or brackish wetlands, with inundated or emergent sedges, saltmarsh or other low vegetation. Also found foraging in sewage	Low – – Few sightings and typically restricted to inside the estuary	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					ponds and flooded paddocks. Northern hemisphere breeding.		
Thalassarche cauta (sensu stricto), Thalassarche cauta cauta	Shy Albatross, Tasmanian Shy Albatross	V	V, M, MA		The Shy Albatross is a marine species occurring in subantarctic and subtropical waters, reaching the tropics in the cool Humboldt Current off South America.	Low – No sightings	Unlikely
Phoebetria fusca	Sooty Albatross	V	-		In Australian waters, this species is generally recorded in winter off the south coast from Tasmania to Western Australia, while there are occasional sightings off the NSW coast, north of Grafton. This pelagic or ocean-going species inhabits subantarctic and subtropical marine waters, spending the majority of its time at sea, and rarely occurs in continental shelf waters.	Low – No sightings	Unlikely
Haematopus fuliginosus	Sooty Oystercatcher	V	-		In NSW the Sooty Oystercatcher occupies rocky headlands, reefs and offshore islands along the entire coast, apparently as a single continuous population.	Known – Some sightings around rocky coastline	Possible
Macronectes giganteus	Southern Giant Petrel	E	E		The Southern Giant Petrel has a circumpolar pelagic range from Antarctica to approximately 20 S and is a common visitor off the coast of NSW. Over summer, the species nests in small colonies amongst open vegetation on Antarctic and subantarctic islands, including Macquarie and Heard Islands and in Australian Antarctic territory.	Low – No sightings	Unlikely
Monarcha trivirgatus	Spectacled Monarch	-	M		Coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. Prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves.	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Lophoictinia isura	Square-tailed Kite	V	-		Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by Woollybutt, Spotted Gum, River Peppermint or Gully Gum. Individuals appear to occupy large hunting ranges of more than 100km^2. They require large living trees for breeding, particularly near water with surrounding woodland-forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	Low – lack of suitable habitat	Unlikley
Lathamus discolor	Swift Parrot	E	CE		The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.	Low – lack of suitable habitat	Unlikely
Gallinago megala	Swinhoe's Snipe	-	M		Occurs at edges of wetlands, swamps and freshwater streams. Also known to occur in grasslands, sewage ponds and drying claypans. Northern hemisphere breeding.	Low – lack of suitable habitat	Unlikely
Xenus cinereus	Terek Sandpiper	V	M, MA		The Terek Sandpiper mostly forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons. Northern hemisphere breeding.	Low – Few sightings and typically restricted to inside the estuary	Unlikely
Diomedea exulans	Wandering Albatross	E	V, M, MA		The Wandering Albatross is marine, pelagic and aerial. The Wandering Albatross visits Australian waters from Fremantle, Western Australia to	Low – No sightings	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					northern New South Wales between June and September each year.		
Numenius phaeopus	Whimbrel	-	M		Usually found on intertidal mudflats of sheltered coasts. Also found in harbours, lagoons, estuaries and river deltas, often those with mangroves. Northern hemisphere breeding.	High – Some sightings along coastline	Unlikely
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	MA		Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	High – suitable foraging habitat	Possible
Hirundapus caudacutus	White-throated Needletail	-	M, MA		An aerial species found in feeding concentrations over cities, hilltops and timbered ranges.	Low – lack of suitable habitat	Unlikely
Ardenna pacifica	Wedge-tailed Shearwater		M, MA		This migratory marine species can nearly always be found over pelagic waters except when at colonies. It breeds on the east and west coasts of Australia, nesting in burrows on off-shore islands or atolls. Known to	Known – Breeds on Cook Island.	Possible
Anous stolidus	Common Noddy		M, MA		Occurs mainly in ocean off the Queensland coast, but the species also occurs off the north-west and central Western Australia coast. Breeds on islands.	Low – Few sightings and typically restricted to inside the estuary	Unlikely
Calonectris leucomelas	Streaked Shearwater		M, MA		This migratory marine bird can be found over both pelagic and inshore waters. It will follow fishing boats. Breeding begins in March in colonies on offshore islands, occupying burrows on forested hills. It undergoes transequatorial migration.	Low – No sighting since 1996	Unlikely
Diomedea epomophora (sensu stricto)	Southern Royal Albatross		V, M, MA		Marine and pelagic. It occurs in subantarctic, subtropical and occasionally Antarctic waters where the water surface temperature is 6 to 20°C Nests on flat or gently sloping ground on slopes, ridges, gullies	Low – No sightings	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					and plateaux of large islands, and on the summits of islets.		
Fregata ariel	Lesser Frigatebird		M, MA		Breeds on small, remote tropical and sub-tropical islands, in mangroves or bushes, and even on bare ground. It feeds mainly on fish (especially flying-fish) and squid, but also on seabird eggs and chicks, carrion and fish scraps	Low – No sightings	Unlikely
Fregata minor	Great Frigatebird		M, MA		Found over open, tropical ocean waters and near offshore, oceanic nesting islands. Nesting colonies are known from offshore islands throughout the tropical Pacific	Low – No sightings	Unlikely
Glareola maldivarum	Oriental Pratincole		M, MA		Widespread in northern areas, especially along the coasts of the Pilbara Region and the Kimberley Division in Western Australia. There are occasional records in southern Australia	Low – No sightings	Unlikely
Thalasseus bergii	Crested Tern		M, MA		Widespread along the coastline and common throughout NSW and southern QLD. They breed in colonies on small offshore islands.	Known – Breeds on Cook Island.	Possible
Tringa glareola	Wood Sandpiper		M, MA		Use well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes. They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation, such as dense stands of rushes or reeds, shrubs, or dead or live trees.	Low – No sightings	Unlikely
Catharacta skua, Stercorarius skua	Great Skua		MA		Avoids land during migration and winter, aggregating in winter in areas where it can scavenge from fisheries. Breeding begins in May, breeding on islands on flat ground with some vegetation cover, usually	Low – No sightings	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					avoiding human contact. Most birds breed within 1 km of their birth place.		
Charadrius ruficapillus	Red-capped Plover		MA		Resident shorebird in Australia. They usually inhabit wide, bare sand flats or mudflats at the margins of saline, brackish or freshwater wetlands where they forage.	Low – Few sightings and typically restricted to inside the estuary	Unlikely
Cuculus optatus	Oriental Cuckoo		M, MA		The Oriental cuckoo has an extremely large range breeding in the northern hemisphere. Migrates to the Malay Peninsula, Indonesia, the Philippines, New Guinea, the Solomon Islands, northern and eastern Australia, and occasionally as far as New Zealand.	Low – No sightings	Unlikely
Himantopus himantopus	Black-winged Stilt		MA		Resident shorebird in Australia. This species occupies the shores of large inland water bodies and estuarine or coastal habitats such as river deltas, coastal lagoons and shallow freshwater or brackish pools with extensive areas of mudflats, salt meadows, saltpans, coastal marshes and swamps.	Moderate – Typically utilises habitat within the estuary	Unlikely
Chroicocephalus novaehollandiae	Silver Gull		MA		Widespread along the east coast, will utilise coastal and inshore habitat. May breed on offshore islands.	Known – Breed in area	Possible
Merops ornatus	Rainbow Bee-eater		MA		Occurs mainly in open forests and woodlands, shrub lands, and in various cleared or semi-cleared habitats. It also occurs in inland and coastal sand dune systems, and in mangroves in northern Australia.	Moderate – Typically utilises habitat within the estuary	Unlikely
Pachyptila turtur	Fairy Prion		MA		Small marine bird that occurs mainly offshore near breeding colonies, and rarely enter sheltered coastal waters. Breeding starts in September and the species	Low – No sightings	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					is highly colonial, creating burrows in coastal sites on oceanic islands.		
Recurvirostra novaehollandiae	Red-necked Avocet		MA		Resident shorebird in Australia, breeding mainly in the south-western interior. Found in large shallow freshwater or saltwater wetlands and estuarine mudflats.	Low – Few sightings and typically restricted to inside the estuary	Unlikely
Thalassarche eremita, Thalassarche cauta eremita	Chatham Albatross		E, M, MA		Marine species that occurs in subantarctic and subtropical waters reaching the tropics. It appears to be largely pelagic and has been noted in shelf-waters around breeding islands, over continental shelves during the non-breeding season, and occurs inshore and offshore. It usually nests on rocky ledges and steep slopes.	Low – No sightings	Unlikely
Thalassarche impavida	Campbell Albatross		V, M, MA		Marine species occurring in subantarctic and subtropical waters. It occurs inshore and offshore over continental shelves, around continents and may enter harbours and bays. Nests on ledges and steep slopes covered in low native grasses, tussocks and mud.	Low – No sightings	Unlikely
Thalassarche salvini	Salvin's Albatross		V, M, MA		Marine species occurring in subantarctic and subtropical waters. It occurs inshore and offshore over continental shelves, around continents and may enter harbours and bays. It breeds mostly on small, bare rocky islands.	Low – No sightings	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Thalassarche cauta steadi, Thalassarche steadi	White-capped Albatross		V, M, MA		Common off the coast of south-east Australia throughout the year. It has been observed that juveniles are rare in New Zealand waters, being more common off south-east Australia and South Africa. Breeding colonies occur on islands south of New Zealand.		
Fish							
Micrognathus andersonii	Anderson's Pipefish, Shortnose Pipefish		MA		Typically found within coastal marine areas that contain seagrasses, macroalgae or coral reefs. Tropical and sub-tropical distribution from northern NSW to northern QLD.	Low – lack of suitable habitat	Unlikely
Hippichthys penicillus	Beady Pipefish, Steep-nosed Pipefish		MA		Typically found within coastal marine areas that contain seagrasses, kelp or coral reefs. Widely distributed throughout temperate and tropical waters from NSW to WA.	Low – lack of suitable habitat	Unlikely
Trachyrhamphus bicoarctatus	Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish		MA		Occupy macroalgae and seagrass beds in coastal areas and estuaries with good tidal exchange, while regularly seen on artificial structures such as pylons and nets	Low – lack of suitable habitat	Unlikely
Epinephelus daemelii	Black Rockcod		V	V	Inhabit coastal waters and estuaries, use caves and crevices around ledges and rock walls as refuge.	Known – Reported to occur in Cook Island Aquatic Reserve	Possible
Hippichthys cyanospilos	Blue-speckled Pipefish, Blue-spotted Pipefish		MA		Typically found within coastal marine areas that contain seagrasses, macroalgae or coral reefs. Tropical and sub-tropical distribution from northern NSW to the western NT coast.	Low – lack of suitable habitat	Unlikely
Syngnathoides biaculeatus	Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish		MA		Typically found within coastal marine areas that contain seagrasses, kelp or coral reefs. Widely distributed throughout temperate and tropical waters along both the east and west coasts.	Low – lack of suitable habitat	Unlikely
Solegnathus dunckeri	Duncker's Pipehorse		MA		Endemic to eastern Australia from southern Queensland to at least Forster. Inhabit deeper reefs	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					(+25m) in association with gorgonian corals, black corals, algae or sponges.		
Corythoichthys amplexus	Fijian Banded Pipefish, Brown-banded Pipefish		MA		Typically found within coastal marine areas that contain seagrasses such as eelgrass or coral reefs. Tropical and sub-tropical distribution from northern NSW to the Kimberley WA.	Low – lack of suitable habitat	Unlikely
Hippocampus planifrons	Flat-face Seahorse		MA		Endemic to tropical Western Australia, from Broome to Dirk Hartog Island. Inhabits algal and rubble reefs in shallow bays from the intertidal to depths of 20 m.	Low – lack of suitable habitat	Unlikely
Festucalex cinctus	Girdled Pipefish		MA		Typically found within coastal marine areas that contain seagrasses, kelp or coral reefs. Also found in sponge and seagrass habitats in sheltered coastal bays with sparse low algal growth.	Low – lack of suitable habitat	Unlikely
Hippocampus kelloggi	Great Seahorse		MA		Central New South Wales to Botany Bay, Sydney. Inhabits reefs and also soft bottom areas, often in association with gorgonian corals and sea whips.	Low – lack of suitable habitat	Unlikely
Pristis zijsron	Green Saw fish		V	PE	Widespread across northern Australia, from about Eighty Mile Beach, Western Australia, to the Cairns region, Queensland. Historically, individuals were taken as far south as Sydney, New South Wales. Green Sawfish inhabit coastal marine and estuarine waters	Low – Presumed extinct in NSW waters	Unlikely
Urocampus carinirostris	Hairy Pipefish		MA		Tropical and temperate South Pacific. In Australia, known from the Shoalwater Bay region (Queensland) to northern Tasmania. Inhabits the lower reaches of rivers, sheltered estuaries and shallow reefs in seagrass and algal beds a 0-6 m.	Low – lack of suitable habitat	Unlikely
Lissocampus runa	Javelin Pipefish		MA		Endemic to temperate waters of southern and eastern Australia; known from southern Queensland, southwards to Tasmania. Usually inhabits tide pools and sheltered bays, usually in seagrass and algal beds, and rocky and shelly rubble bottoms in depths to about 20 m.	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Hippichthys heptagonus	Madura Pipefish, Reticulated Freshwater Pipefish		MA		Widespread in the tropical Indo-West Pacific; inhabits inshore mangrove estuaries, tidal creeks and the lower reaches of freshwater streams.	Low – lack of suitable habitat	Unlikely
Microphis manadensis	Manado Pipefish, Manado River Pipefish		MA		Tropical Western Pacific from Indonesia, Australia, Papua New Guinea, the Philippines, Taiwan, Palau, the Solomon Islands; known in Australia from a single questionable record from Moreton Bay, Queensland; inhabits estuaries, freshwater streams and rivers up to 30 km from the mouth.	Low – lack of suitable habitat	Unlikely
Vanacampus margaritifer	Mother-of-pearl Pipefish		MA		Endemic to sub-tropical and temperate Australia, from North Stradbroke Island, QLD, southwards to Jurien Bay, WA, absent from Tasmania. Inhabits shallow estuarine and coastal waters where it occurs in seagrass beds, rocky reef, boulder, rubble, sandy and muddy habitats between 2-15 m.	Low – lack of suitable habitat	Unlikely
Halicampus grayi	Mud Pipefish, Gray's Pipefish		MA		Widespread in the tropical Indo-west Pacific, from the Gulf of Aden across the Indian Ocean to northern Australia, north to Japan; inhabits silty and muddy soft bottoms on the continental shelf from inshore bays to deep offshore areas to 100 m.	Low – lack of suitable habitat	Unlikely
Corythoichthys ocellatus	Orange-spotted Pipefish, Ocellated Pipefish		MA		Tropical Western Central Pacific, from Indonesia, the Philippines, Palau, Papua New Guinea, the Solomon Islands, Fiji and Australia. Known from the Great Barrier Reef, Queensland; inhabits coral rubble, algal reefs and inshore areas to about 15 m.	Low – lack of suitable habitat	Unlikely
Solenostomus paradoxus	Ornate Ghostpipefish, Harlequin Ghost Pipefish,		MA		Widespread in tropical and warm-temperate regions. Inhabit protected coastal, lagoon and outer reef areas with drop-offs or rock faces, in depths of 3-35 m. They often associate with crinoids (featherstars), gorgonians and black corals.	Low – lack of suitable habitat	Unlikely
Solegnathus hardwickii	Pallid Pipehorse, Hardwick's Pipehorse		MA		Coastal species that occurs in waters from Kyushu, Japan to New South Wales and Western Australia	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Solenostomus cyanopterus	Robust Ghostpipefish, Blue-finned Ghost Pipefish		MA		Widespread in the tropical Indo-west Pacific. Known in Australian waters from the Shark Bay region, Western Australia, around the tropical north and southwards to at least Sydney Harbour, New South Wales. Live in protected coastal and lagoon reefs, deeper coastal reefs and deep, clear estuaries with seagrass or macro-algae in 15-25m.	Low – lack of suitable habitat	Unlikely
Solenostomus paegnius	Rough-snout Ghost Pipefish		MA		Found in tropical Indo-Pacific Ocean from East Afric to Australia, north to Japan.	Low – lack of suitable habitat	Unlikely
Maroubra perserrata	Sawtooth Pipefish		MA		Endemic to temperate southern Australian waters from southern Queensland to Rottnest Island, Western Australia. Inhabits coastal reefs at depths of 3-25m, sheltering beneath ledges and in caves during day.	Low – lack of suitable habitat	Unlikely
Acentronura tentaculata	Shortpouch Pygmy Pipehorse		MA		Found on tropical inshore reefs. It also occurs in temperate waters associated with shallow sandflats in protected and somewhat silty coastal areas among sparse low plant growth and in algae on rocks.	Low – lack of suitable habitat	Unlikely
Thunnus maccoyii	Southern Blue Fin Tuna		CD	E	Circumglobal in temperate and cold temperate waters of the southern hemisphere, ranging across the Pacific, mostly between 30°S and 50°S, to almost 60°S (rare in the Eastern Pacific). Southern Bluefin Tuna breed between October and March in an area off Java, Indonesia.	Low – May be transient	Unlikely
Solegnathus spinosissimus	Spiny Pipehorse, Australian Spiny Pipehorse		MA		Known from temperate waters of Australia and New Zealand from Caloundra to southern Tasmania Inhabit relatively shallow waters. Specimens have been collected from muddy, silty, shelly and rubble substrates, and rocky reefs, and may be washed ashore after storms.	Low – lack of suitable habitat	Unlikely
Hippocampus kuda	Spotted Seahorse		MA		Inhabiting shallow inshore waters normally between 0-8 m depth with a maximum recorded depth of up to 55 m. Found in inhabit coastal bays, harbours and lagoons, sandy sediments in rocky littoral zones,	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					macroalgae and seagrass beds, mangroves, muddy bottoms, and shallow reef flats.		
Micrognathus brevirostris	thorntail Pipefish, Thorn-tailed Pipefish		MA		Tropical waters to Southport, Queensland. Inhabits sheltered coral reef lagoons, inner and seaward reefs, usually in crevices, small caves and gutters, mostly below 10 m, but collected as deep as 20m.	Low – lack of suitable habitat	Unlikely
Hippocampus trimaculatus	Three-spot Seahorse		MA		Occurs on the Australian east coast. Most often found at depths greater than 10 m with a maximum reported depth for this species being 100 m. This species utilizes soft substrates such as sand and mud as well as macro algae and soft corals.	Low – lack of suitable habitat	Unlikely
Filicampus tigris	Tiger Pipefish		MA		Relatively common in subtropical waters of Australia's east and west coasts. A relic population also occurs in the warmer waters of Spencer Gulf, South Australia. Inhabits shallow seagrass beds and sponge, mud, sand, rock, and rubble areas in depths of 2-30 m.	Low – lack of suitable habitat	Unlikely
Campichthys tryoni	Tryon's Pipefish		MA		Endemic to Queensland, from Lindeman Island to the Gold Coast. Inhabits shallow rubble areas in estuaries, inner reef flats and reef margins bordering sand channels.	Low – lack of suitable habitat	Unlikely
Hippocampus whitei	White's Seahorse		MA		White's Seahorse is found only from Wallis Lake to Lake Illawarra in New South Wales, although potential distribution extends from VIC to QLD. It occurs in shallow weedy areas in estuaries, bays and harbours, usually attached to seagrass, sponges and kelp holdfasts - and the netting of public harbour pools.	Low – lack of suitable habitat	Unlikely
Stigmatopora nigra	Widebody Pipefish, Wide-bodied Pipefish, Black		MA		Typically found within coastal marine areas that contain seagrasses or kelp. Distributed throughout temperate and subtropical waters from southern QLD, around southern Australia to the central WA coast.	Low – lack of suitable habitat	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Carcharius taurus	Grey Nurse Shark		E	CE	Grey nurse sharks are found primarily in warm temperate inshore waters around rocky reefs and islands, in or near deep sandy-bottomed gutters or rocky caves, and occasionally in the surf zone and shallow bays. They have been recorded at varying depths down to 230 m on the continental shelf but are most commonly found between 15–40 m. Critical habitats and key aggregation sites exist adjacent to the region in New South Wales and southern Queensland state waters, as well as several in Commonwealth waters at the Cod Grounds and Solitary islands.	Known – reported to occur in Cook Island Aquatic Reserve	Possible
Sphyrna lewini	Scalloped Hammerhead Shark			E	Oceanic species that inhabitant continental shelf waters	Low – May be transient visitor at times	Unlikely
Carcharodon carcharias	Great White Shark		V, MA	V	Great White Sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski et al. 2002 in DEWHA 2009). They also make open ocean excursions and can cross ocean basins (for instance from South Africa to the western coast of Australia and from the eastern coast of Australia to New Zealand). Great White Sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA 2009).	High – May forage in the area at times	Unlikley
Mammals							
Arctocephalus pusillus	Australian Fur-seal	V	MA		Reported to have bred at Seal Rocks, near Port Stephens and Montague Island in southern NSW. Haul outs are observed at isolated places along the NSW coast.	Low – May be transient	Unlikely
Balaenoptera musculus	Blue Whale	E	E, M		Widespread and likely that the whales occur around the continent at various times of the year. However, much of the Australian continental shelf and coastal	Low – May be transient	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					waters have no particular significance to the whales and are used only for migration and opportunistic feeding. The only known areas of significance to the blue whale are feeding areas around the southern continental shelf.		
Balaenoptera brydei, B. edeni	Bryden's Whale		M		Bryde's Whale is found in temperate to tropical waters exceeding 16.3 °C, but generally those 20 °C or warmer.	Low – May be transient	Unlikely
Dugong dugon	Dugong	E	M, MA		Range of the dugong is broadly coincident with the distribution of seagrasses in the tropical and sub-tropical waters in their Australian range. Common from Morten Bay north.	Low – May be transient	Unlikely
Lagenorhynchus obscurus	Dusky Dolphin		M		Coastal species that is rarely seen inside estuaries. They are primarily found from about 55° to 26°S, with extensions well northwards in association with cold currents. Common in nearshore areas in SE Australia	Low – Typically north of their range.	Unlikely
Megaptera novaeangliae	Humpback Whale	V	V, M		The population of Australia's east coast migrates from summer cold-water feeding grounds in subantarctic waters to warm-water winter breeding grounds in the central Great Barrier Reef (OEH 2019).	High	Unlikely
Sousa chinensis *Sousa sahulensis*	Indo-Pacific Humpback Dolphin		M		Australian humpback dolphins are found in tropical/subtropical waters of the Sahul Shelf from northern Australia to the southern waters of the island of New Guinea. In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from approximately the Queensland–New South Wales border to western Shark Bay, Western Australia.	Low – Extend of southern range, likely transient	Unlikley
Orcinus orca	Killer Whale		M		Killer Whales are recorded from all states, with concentrations reported around Tasmania and frequent sightings in South Australia and Victoria.	Low – May be transient	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					The preferred habitat of Killer Whales includes oceanic, pelagic and neritic		
Arctocephalus forsteri	New Zealand Fur-seal	V			Occurs in Australia and New Zealand. Reports of non-breeding animals along southern NSW coast particularly on Montague Island, but also at other isolated locations to north of Sydney	Low – May be transient	Unlikely
Caperea marginata	Pygmy Right Whale		M		Records of Pygmy Right Whales in Australian waters are distributed between 32° S and 47° S but are not uniformly spread around the coast.	Low – North of typical range	Unlikely
Eubalaena australis	Southern Right Whale	E	E, M		Migrate between summer feeding grounds in Antarctica and winter breeding grounds around the coasts of southern Australia, New Zealand, South Africa and South America. They feed in the open ocean in summer. They move inshore in winter for calving and mating.	Low – May be transient	Unlikely
Physeter macrocephalus	Sperm Whale	V			Wide, but patchy distribution from the tropics to the edge of the polar pack-ice in both hemispheres. Concentrations of Sperm Whales tend to occur where the seabed rises steeply from a greater depth, beyond the continental shelf.	Low – May be transient	Unlikely
Balaenoptera borealis	Sei Whale		V		Sei whales are considered a cosmopolitan species, ranging from polar to tropical waters, but tend to be found more offshore than other species of large whales.	Low – May be transient	Unlikely
Orcaella heinsohni	Snubfin Dolphin		M		All available data on the distribution and habitat preferences of Australian Snubfin Dolphins indicate that they mainly occur in one location: shallow coastal and estuarine waters of Queensland, Northern Territory and north Western Australia.	Moderate – Within southern extent of known range	Unlikely
Balaenoptera acutorostrata	Minke Whale		M		Widely distributed throughout the Southern Hemisphere. Are believed to move between subantarctic waters and the GBR between March and November.	Low – May be transient	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
Grampus griseus	Risso's Dolphin		M		Risso's Dolphin occur mainly on steep sections of the upper continental slope (Baumgartner 1997), usually in waters deeper than 1000 m (Ross 1984), in tropical and warm temperate latitudes	Low – Typical utilise offshore habitat	Unlikely
Stenella attenuata	Spotted Dolphin		M		Marine species that prefers open seas. Found in nearshore and offshore waters from Sydney, throughout northern Australia to Perth.	Low – Typical utilise offshore habitat	Unlikely
Tursiops aduncus	Spotted Bottlenose Dolphin		M		Restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands.	High –foraging habitat	Possible
Tursiops truncatus	Bottlenose Dolphin		M		Bottlenose Dolphins are found in all temperate and tropical waters around the world, in both coastal (inshore and nearshore) and offshore waters.	High –foraging habitat	Possible
Reptiles							
Natator depressus	Flatback Turtle		V, M		Post-hatchling and juvenile Flatback Turtles do not have the wide dispersal phase in the oceanic environment like other sea turtles. Adults inhabit soft bottom habitat over the continental shelf of northern Australia.	Low – outside adult geographic habitat range	Unlikely
Chelonia mydas	Green Turtle	V	V, M		Green Turtles occur in seaweed-rich coral reefs and inshore seagrass pastures in tropical and subtropical areas of the Indo-Pacific region.	Known – Cook Island	Possible
Eretmochelys imbricata	Hawksbill Turtle		V, M		Hawksbill Turtles spend their first five to ten years drifting on ocean currents. Hawksbill Turtles have been seen in temperate regions as far south as northern NSW.	Moderate – marginal foraging habitat	Possible
Dermochelys coriacea	Leatherback Turtle	E	E, M		Occurs in inshore and offshore marine waters. Rarely breeds in Australia, with the nearest regular nesting sites being the Solomon Islands and Malayan Archipelago. Occasional breeding records from NSW	Low – Mainly pelagic, may be transient at times	Possible

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					coast, including between Ballina and Lennox Head in northern NSW.		
Caretta caretta	Loggerhead Turtle	E	E, M		Loggerhead turtles have a worldwide tropical and subtropical distribution. In Australia, they occur in coral reefs, bays and estuaries in tropical and warm temperate waters off the coast of Queensland, Northern Territory, Western Australia and New South Wales.	Known – Cook Island	Possible
Lepidochelys olivacea	Pacific Ridley Turtle		E, M, MA		The Olive Ridley Turtle has a circumtropical distribution, with nesting occurring throughout tropical waters (except the Gulf of Mexico) and migratory circuits in tropical and some subtropical areas. Associated with offshore areas and rarely seen on exposed coastal and reef areas	Low – may be transient	Unlikely
Astrotia stokesii	Stokes' Seasnake		MA		The Stokes' Seasnake inhabits the tropical seas of northern Australia, including Western Australia, the Northern Territory and Queensland. May occur at times in northern NSW waters.	Low – may be a transient visitor at times	Unlikely
Hydrophis elegans	Elegant Seasnake		MA		The Elegant Seasnake is widespread in tropical Australia. This includes Queensland, Western Australia and the Northern Territory. Its distribution extends from Shark Bay in Western Australia to the Nortehrn NSW Coast during summer months.	Low – may be a transient visitor at times	Unlikely
Sharks and Rays							
Manta birostris	Giant Manta Ray		M		Widespread, although relatively uncommon in Australian waters; also, Cocos (Keeling) Islands and Christmas Island in the eastern Indian Ocean. Elsewhere the species is circumglobal – usually offshore, often around oceanic islands, sometimes coastal, and most common in tropical waters.	Low – lack of suitable habitat	No
Sphyrna lewini	Scalloped Hammerhead Shark			E	Known in Australian waters from about Geographe Bay, Western Australia, around the tropical north, to	High –foraging habitat	Possibly

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					Sydney, New South Wales. Elsewhere, widespread in tropical and warm temperate seas.		
Sphyrna mokarran	Great Hammerhead Shark			V	The Great Hammerhead Shark is primarily oceanic has a circumglobal distribution in tropical and warm temperate seas from latitudes 40° N to 35° S, however the species has been recorded as far south as Sydney (34°).	Low – May be transient visitor at times	Unlikely
Manta alfredi	Reef Manta Ray		M		Known on Australian waters from about Perth, Western Australia, around the tropical north to the Solitary Islands, New South Wales. Elsewhere the species is circumglobal in tropical waters. Often seen inshore around coral and rocky reefs in tropical and subtropical waters. Also occur around offshore reefs and seamounts.	High –foraging habitat	Possibly
Carcharius taurus	Grey Nurse Shark		E	CE	Grey nurse sharks are found primarily in warm temperate inshore waters around rocky reefs and islands, in or near deep sandy-bottomed gutters or rocky caves, and occasionally in the surf zone and shallow bays. They have been recorded at varying depths down to 230 m on the continental shelf but are most commonly found between 15–40 m. Critical habitats and key aggregation sites exist adjacent to the region in New South Wales and southern Queensland state waters, as well as several in Commonwealth waters at the Cod Grounds and Solitary islands.	Known – reported to occur in Cook Island Aquatic Reserve	Possible
Sphyrna lewini	Scalloped Hammerhead Shark			E	Oceanic species that inhabitant continental shelf waters	Low – May be transient visitor at times	Unlikely
Carcharodon carcharias	Great White Shark		V, MA	V	Great White Sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski et al. 2002 in DEWHA 2009). They also make open ocean excursions and can cross ocean	High – May forage in the area at times	Unlikely

Threatened species		Legislation			Habitat description	Likelihood of occurrence	Potential to impact
Scientific Name	Common Name	BC Act	EPBC Act	FM Act			
					basins (for instance from South Africa to the western coast of Australia and from the eastern coast of Australia to New Zealand). Great White Sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA 2009).		
Lamna nasus	Mackerel Shark		M		Oceanic species that in habitat continental shelf waters	Low	Unlikely
Rhincodon typus	Whale Shark		V, M		Oceanic species that in habitat continental shelf waters. At times seen in Coastal waters, rarely seen in NSW waters.	Low – May be a transient visitor at times	Unlikely
Plants							
Chamaesyce psammogeton	Sand Spurge	E			Found sparsely along the coast from south of Jervis Bay (at Currarong, Culburra and Seven Mile Beach National Park) to Queensland (and Lord Howe Island). Populations have been recorded in Wamberal Lagoon Nature Reserve, Myall Lakes National Park and Bundjalung National Park. Grows on fore-dunes and exposed headlands, often with *Spinifex sericeus*.	Low – lack of suitable habitat	No

Appendix 2 – Assessments of Significance (BC Act) and Significant Impact Criteria assessment (EPBC Act)

Five Part Tests have been conducted on threatened species listed under the BC Act, while a Seven Part Test (under the EP&A Act) has been used for species listed under the FM Act. For MNES listed under the EPBC Act, Significant Impact Criteria assessments have been undertaken. Note: the MNES do not include other matters protected under the EPBC Act e.g. Cetaceans and Marine species.

Unless otherwise stated – the habitat and general ecological information contained in the assessment of significance has been taken from the NSW Office of Environment and Heritage (OEH) Threatened Species Profiles database (DECC 2008) and/or the Commonwealth SPRAT database (SEWPaC 2012):

- http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/
- http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Definitions

The following definitions are taken from the OEH Threatened Species Assessment Guidelines: The Assessment of Significance (DECC 2007) and have been adopted for this assessment.

Subject site: the area to be directly affected by the proposal.

Study area: the subject site and any additional areas which may potentially be affected by the proposal either directly or indirectly.

Direct impacts: those that directly affect the habitat and/or individual plants and animals and cannot be avoided or mitigated.

Indirect impacts: those that affect species, populations or ecological communities in a manner other than through direct loss or disturbance. These can usually be avoided or mitigated.

Local population: the population of a particular species that occurs in the locality.

Locality: the area within 10 km of the study area

Seabirds

Seabirds (these will be assessed as one group which includes all the species in the table below)

Scientific Name	Common Name	FM Act	BC Act	EPBC Act	Potential Impact
Pandion cristatus	Eastern Osprey		V	M	Foraging habitat
Puffinus carneipes *Ardenna carneipes*	Flesh-footed Shearwater		V		Foraging habitat
Apus pacificus	Fork-tailed Swift			M	Foraging habitat
Sternula albifrons	Little Tern		E	M	Foraging habitat
Haliaeetus leucogaster	White-bellied Sea-eagle		V		Foraging habitat
Ardenna pacifica	Wedge-tailed Shearwater			M	Foraging habitat Breeds on Cook Island
Thalasseus bergii	Crested Tern			M	Foraging habitat

Scientific Name	Common Name	FM Act	BC Act	EPBC Act	Potential Impact
					Breeds on Cook Island

A summary of migratory patterns and habitat use is provided in the table below

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
Pandion cristatus	Adult Eastern Ospreys are mostly resident or sedentary around breeding sites within their large territories. They forage more widely but continue to make at least intermittent visits to their breeding grounds in the non-breeding season.	Eastern Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia.	Nests are constructed in a variety of natural and artificial sites including in dead or partly dead trees or bushes; on cliffs, rocks, rock stacks or islets; on the ground on rocky headlands, coral cays, deserted beaches, sandhills or saltmarshes; and on artificial nest platforms, pylons, jetties, lighthouses, navigation towers, cranes, exposed shipwrecks and offshore drilling rigs.	Eastern Ospreys mainly feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals. They usually forage diurnally, but have also been observed hunting at night
Puffinus carneipes *Ardenna carneipes*	The Flesh-footed Shearwater is a trans-equatorial migrant. The species is widely distributed across the southern Indian and south-western Pacific Oceans during the breeding season. Individuals from eastern colonies migrate north to the northern Pacific Ocean after breeding season.	Diurnal loafing and probably some nocturnal roosting occur at sea.	In NSW they nest on Lord Howe Island in forests on sandy soils from Ned's Beach to Clear Place, with smaller colonies below Transit Hill and at Old Settlement Beach.	The Flesh-footed Shearwater forages almost entirely at sea and very rarely on land.
Apus pacificus	The Fork-tailed Swift leaves its breeding grounds in Siberia from August–September and usually arrives in Australia around October.	The Fork-tailed Swift is almost exclusively aerial.	The Fork-tailed Swift does not breed in Australia.	The Fork-tailed Swift is an aerial eater, flying anywhere from 1 m to 300 m above the ground to forage. They forage along the edge of low-pressure systems and for that reason are considered a precursor to unsettled weather. They often occur over cliffs and beaches and also over islands and sometimes well out to sea.
Sternula albifrons	The eastern Australian subpopulation is migratory, breeding in spring-summer and leaving colonies late summer-autumn and largely vacating southern Australia. The non-breeding range of this population is poorly known, but Australian birds have been recorded in Indonesia. Birds returned to their	Little Terns usually roost or loaf on sand-spits, banks and bars within sheltered estuarine or coastal environments, or on the sandy shores of lakes and ocean beaches The species is not known to use refuge habitats.	Little Terns nest on sand-spits, banks, ridges or islets in sheltered coastal environments, such as coastal lakes, estuaries and inlets, and also on wide and flat or gently sloping sandy ocean beaches, and also, occasionally, in sand-dunes. Breed during September to November.	Little Terns are primarily diurnal, and feed by plunging in shallow water of channels and estuaries, or in surf on beaches, typically from 3–10 m above the surface though up to 13 m above water.

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
	breeding sites in late winter-early spring.		Generally nesting occurs from October through January-February (NSW NPWS, 2003).	
Haliaeetus leucogaster	The White-bellied Sea-Eagle is described as a breeding resident throughout much of its range in Australia.	The White-bellied Sea-Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands.	Nests may be built in a variety of sites including tall trees (especially *Eucalyptus* species), bushes, mangroves, cliffs, rocky outcrops, caves, crevices, on the ground or even on artificial structures. Pairs usually return to the same breeding territory each year, and often the same nest, although territories tend to contain one or two additional, less developed nests.	The White-bellied Sea-Eagle generally forages over large expanses of open water; this is particularly true of birds that occur in coastal environments close to the sea-shore, where they forage over in-shore waters.
Ardenna pacifica	NSW and Lord Howe Island populations migrate north to Papua New Guinea and then west to the Philippines during the non-breeding season.	This species is pelagic.	The species breeds throughout its known range, mainly on vegetated islands, atolls and cays, including Cook Island, but one colony is known on the Australian mainland. Breeding occurs between August and December along the NSW Coast (DoE 2019b).	In Australia, Wedge-tailed Shearwaters have been observed feeding along the junction between inshore and offshore water masses
Thalasseus bergii	All populations of Greater Crested Tern disperse after breeding.	Often roosts on boats and jetties.	Breeds in large dense colonies on small islands, including Cook Island. Breeding in south-eastern Australia typically occurs between September and January.	Forages by plunging several metres into water.

5 Part Test

Seabirds listed under the BC Act

Eastern Osprey (*Pandion cristatus*): Vulnerable

Flesh-footed Shearwater (*Puffinus carneipes*): Vulnerable

Little Tern (*Sternula albifrons*): Endangered

White-bellied Sea-eagle (*Haliaeetus leucogaster*): Vulnerable

(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The proposal has the potential to reduce the quality foraging habitat for seabirds. The deposition of sediment may mobilise sediments, increase turbidity and reduce the ability of seabirds to detect and catch prey items in the study area. Given that these seabirds forage over a very large area (the study area likely constitutes only a very small portion of their foraging range) these impacts are likely to be minimal and restricted to small localised (approximately 50 m in radius) pulse events following the deposition of sediment. There is also potential that increased vessel movements will increase the potential for noise disturbance of foraging seabirds in the study area. Such impacts are likely to be minimal, occur infrequently and would be short-term occurring while the sediment is deposited from the vessel.

The Little Tern nests along beaches in northern NSW, and there are historic sightings that pre-date 1980 of nesting pairs at Fingal Head (NSW NPWS 2003). Furthermore, the site has high levels of human activity resulting in disturbances that are likely to limit the likelihood and success of any nesting on the sand spit at Fingal Head.

The proposal is unlikely to adversely affect the life cycles of these seabirds such that local populations of the species are likely to be placed at risk of extinction.

(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

NA

(c) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality

i. No habitat for these species will be removed as a result of the proposed action. Small areas of foraging habitat may be temporarily modified as turbidity may increase during and after deposition events in the study area.

ii. The relatively small marine area likely to be temporarily affected is surrounded by other foraging habitat and fragmentation is unlikely.

iii. The study area is unlikely to constitute important foraging habitat site to seabirds given the presence of extensive areas of suitable foraging habitat around the site and as such is unlikely to affect long term survival of the species.

(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).

No

(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process

KTPs that are likely to be exacerbated by the proposed development include:

- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
- the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW

these KTPs would be mitigated through on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site).

Conclusion The populations of Eastern Ospreys, Flesh-footed Shearwaters, Little Terns, White-bellied Sea-eagles that may utilise foraging habitat around Fingal Head are unlikely to be significantly affected by the proposed activity.

Significance Impact Criteria

Seabirds listed under the EPBC Act	
Eastern Osprey (*Pandion cristatus*): Migratory	
Fork-tailed Swift (*Apus pacificus*): Migratory	Likelihood
Little Tern (*Sternula albifrons*): Migratory	
Wedge-tailed Shearwater (*Ardenna pacifica*): Migratory	
Crested Tern: Migratory (*Thalasseus bergii*): Migratory	

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

1. **lead to a long-term decrease in the size of a population for endangered species, important population for vulnerable species**

NA	NA
2. reduce the area of occupancy of an endangered species, important population for vulnerable species	
NA	NA
3. fragment an existing population into two or more populations for an endangered or vulnerable species	
NA	NA
4. adversely affect habitat critical to the survival of a species	
NA	NA
5. disrupt the breeding cycle of a population	
NA	NA
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	
NA	NA
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;	
NA	NA
8. introduce disease that may cause the species to decline, or	
NA	NA
9. interfere substantially with the recovery of the species.	
NA	NA
For listed migratory species	
10. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	
The proposed action may temporarily reduce the quality of potential foraging habitat at times due to poorer water quality from the mobilisation of sediments during sand deposition events but is not predicted to result in a substantial modification of the foraging habitat. Given that these sea birds forage over very large areas (much larger than the study area) and the visible plume is expected to be very localised, there is minimal potential for substantial modification of the habitat of migratory seabird species. Thus, it is unlikely the proposed action has potential to substantially modify destroy or isolate an area of important habitat.	Unlikely
11. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	
It is unknown whether the area to be affected is important habitat. The area of potential foraging habitat that may be affected is relatively small; the study area is surrounded by extensive areas of similarly suitable potential foraging habitat and these birds may forage over very large areas, much larger than the study area. As such, it is unlikely that these species are solely dependent on the resources within the study area for survival and thus the potential foraging habitat in the study area is unlikely to constitute important habitat for these species. Implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species. As such, the proposed action is unlikely to result in invasive species becoming established in an area of important habitat for migratory seabirds.	Unlikely
12. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	
Potential impacts of the proposal on the lifecycle of migratory seabird species are predicted to be limited primarily to potential temporal decreases in foraging habitat. As discussed above, it is unlikely the proposed action has potential to substantially modify, destroy or isolate an area of important habitat. Some migratory birds are known to nest on adjacent Cook Island, however this breeding habitat is not expected to be directly impacted by the proposal with sufficient buffers for noise provided by the Marine Reserve boundaries. There is also potential nesting habitat for the Little Tern on the sand spit at Fingal Head, however there are few recent records of nesting success at this site, and it is impacted by high levels of human disturbance. As such, potential impacts from the proposed action are unlikely to seriously disrupt the lifecycle or the population of any migratory species.	Unlikely
Conclusion:	The proposal is unlikely to result in a significant impact on any migratory seabirds considered as part of this assessment.

Wading Shorebirds

Wading Shorebirds (these will be assessed as one group which includes all the species in the table below)

Scientific Name	Common Name	BC Act	EPBC Act	Potential Impact
Esacus neglectus	Beach Stone Curlew	CE	MA	Foraging, roosting and breeding habitat
Charadrius bicinctus	Double-banded Plover		M	Foraging and roosting habitat
Numenius madagascariensis	Eastern Curlew	-	CE, M	Foraging and roosting habitat
Arenaria interpres	Ruddy Turnstone	-	M	Foraging and roosting habitat
Haematopus longirostris	Pied Oystercatcher	E		Foraging, roosting and breeding habitat
Haematopus fuliginosus	Sooty Oystercatcher	V		Foraging, roosting and breeding habitat
Numenius phaeopus	Whimbrel	-	M	Foraging habitat

A summary of migratory patterns and habitat use is provided in the table below

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
Esacus neglectus	NA	Beaches, islands, reefs and in estuaries, and may often be seen at the edges of or near mangroves	Breed above the littoral zone, at the backs of beaches, or on sandbanks and islands, among low vegetation of grass, scattered shrubs or low trees; also, among open mangroves. Their nests are just a shallow scrape in sand or gravel, above the tidal zone at the backs of beaches, or on sandbanks and islands or among open mangroves. Breed in NSW between October and March	They forage in the intertidal zone of beaches and estuaries, on islands, flats, banks and spits of sand, mud, gravel or rock, and among mangroves.
Charadrius bicinctus	The Double-banded Plover is partly migratory and dispersive. Most birds undertake long-distance migrations to northern New Zealand or south-east and south-west Australia, but others are sedentary. Movement patterns vary regionally.	Roosts on bare open areas or among vegetation and on offshore islets. Roosting sites may be near feeding areas or hundreds of metres away	Breeds in New Zealand	Forages amongst littoral, estuarine and fresh or saline terrestrial wetlands and also saltmarsh, grasslands and pasture. It occurs on muddy, sandy, shingled or sometimes rocky beaches, bays and inlets, harbours and margins of fresh or saline terrestrial wetlands such as lakes, lagoons and swamps, shallow estuaries and rivers. The species is sometimes associated with coastal lagoons, inland saltlakes and saltworks. It is also found on seagrass beds, especially Zostera, which, when exposed at low tide, remain heavily saturated or have numerous water-filled depressions.
Numenius madagascariensis	After breeding, they move south for the	Roosts during high tide periods on sandy spits,	Does not breed in Australia. Nest in the	Forages during the non-breeding season on soft

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
	Northern Hemisphere winter. The birds arrive in north-west and eastern Australia as early as July.	sandbars and islets, especially on beach sand near the high-water mark, and among coastal vegetation including low saltmarsh or mangroves. They occasionally roost on reef-flats, in the shallow water of lagoons and other near-coastal wetlands.	Northern Hemisphere summer.	sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on saltflats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline. The birds are rarely seen on near-coastal lakes or in grassy areas.
Arenaria interpres	Two routes of migration to Australia, with birds occurring in east Australia and New Zealand arriving from a migration south across the Pacific from east Asia and returning north via the east coast of Asia.	Roosts on beaches, above the tideline, among rocks, shells, beach cast seaweed or other debris. They have also been observed roosting on rocky islets among grassy tussocks, and on mudflats and sandflats.	Does not breed in Australia.	Forages between lower supralittoral and lower littoral zones of foreshores, from strand-line to wave-zone. They often forage among banks of stranded seaweed or other tide-wrack. They are also known to forage on exposed rocky platforms, coral reefs and mudflats
Haematopus longirostris	NA	Prefers mudflats, sandbanks and sandy ocean beaches. Roosts at high tide mark.	Nests mostly on coastal or estuarine beaches although occasionally they use saltmarsh or grassy areas. Nests are shallow scrapes in sand above the high tide mark, often amongst seaweed, shells and small stones. Nesting takes place on sand, shell grit or shingle just above high-water mark on beaches, sandbars, margins of estuaries and lagoons. Breeds in NSW between late Winter and Summer.	Forages on exposed sand, mud and rock at low tide, for molluscs, worms, crabs and small fish. The chisel-like bill is used to pry open or break into shells of oysters and other shellfish.
Haematopus fuliginosus	NA	Favours rocky headlands, rocky shelves, exposed reefs with rock pools, beaches and muddy estuaries.	Breeds in spring and summer, almost exclusively on offshore islands, and occasionally on isolated promontories. They nest in a scrape on the ground among pebbles or shells on rocky shores or cliffs.	Forages on exposed rock or coral at low tide for foods such as limpets and mussels.
Numenius phaeopus	Whimbrels are migratory, moving north from Australia to breed in the northern hemisphere, leaving the north and north east coasts by late April. On return to Australia, they move down the coast of	Regularly roost in mangroves and other structures flooded at high tide. They often roost in the branches of mangroves around mudflats and in estuaries and occasionally in tall coastal trees.	Does not breed in Australia.	Forages on intertidal mudflats, along the muddy banks of estuaries and in coastal lagoons, either in open unvegetated areas or among mangroves. They sometimes forage on sandy beaches or among rocks. It has occasionally been sighted feeding on exposed

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
	east Asia, leaving the breeding areas in July, along the East Asian-Australasian Flyway.			coral or rocky reefs and rock platforms.

5 Part Test

Wading Shorebirds listed under the BC Act

Beach Stone Curlew (*Esacus neglectus*): Critically Endangered

Pied Oystercatcher (*Haematopus longirostris*): Endangered

Sooty Oystercatcher (*Haematopus fuliginosus):* Vulnerable

(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The proposal has the potential to reduce habitat quality and/or modify foraging habitat for wading shorebirds. The deposition of sediment may mobilise sediments, increase turbidity and modify (likely increase) sandy sediments in low intertidal areas in places along the beach. Any changes in sand accumulation in intertidal sections of the beach is likely to be minimal in comparison with naturally occurring events. The sand to be deposited is less than 10% per annum of the averaged long-term sediment transport along the coast. There is also potential that increased vessel movements close to shore will increase the potential for noise disturbance of wading shore birds foraging at low tide. Such impacts are likely to be minimal, occur infrequently and be very short-term, while the sediment is deposited from the vessel.

Nesting and roosting habitat of wading shorebirds is predominantly above the high-water mark and beyond the area where indirect impacts are predicted to potentially occur as a result of this proposal.

It is unlikely the proposal will adversely affect the life cycles of these wading shorebirds such that local populations of the species are likely to be placed at risk of extinction.

(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

NA

(c) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality

i. No habitat for these species will be removed as a result of the proposed action. Habitat may be temporarily modified with the possibility of very localised and episodic increases in turbidity only.

ii. The proposal does not have potential to fragment any habitat used for foraging by wading shorebirds.

iii. The area that may potentially be temporally modified is only a very small area in relation to the important foraging habitat used at the locality by these wading shorebird species.

(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).

No

(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process

KTPs that are likely to be exacerbated by the proposed development include:

- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
- the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW

these KTPs would be mitigated through on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site)

Conclusion	The populations of Beach Stone Curlew, Pied Oystercatchers, and Sooty Oystercatchers that may utilise habitat around Fingal Head are unlikely to be significantly affected by the proposed activity.

Significance Impact Criteria

Wading Shorebirds listed under the EPBC Act Double-banded Plover (*Charadrius bicinctus*): Migratory Eastern Curlew (*Numenius madagascariensis*): Critically Endangered, Migratory Ruddy Turnstone (*Arenaria interpres*): Migratory Whimbrel (*Numenius phaeopus*): Migratory	Likelihood
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
1. lead to a long-term decrease in the size of a population for endangered species, important population for vulnerable species	
NA	NA
2. reduce the area of occupancy of an endangered species, important population for vulnerable species	
NA	NA
3. fragment an existing population into two or more populations for an endangered or vulnerable species	
NA	NA
4. adversely affect habitat critical to the survival of a species	
NA	NA
5. disrupt the breeding cycle of a population	
NA	NA
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	
NA	NA
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;	
NA	NA
8. introduce disease that may cause the species to decline, or	
NA	NA
9. interfere substantially with the recovery of the species.	
NA	NA
For listed migratory species	
10. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	
The proposal has the potential to reduce habitat quality and/or modify foraging habitat for wading shorebirds. The deposition of sediment may mobilise sediments, increase turbidity and modify (likely increase) sandy sediments in low intertidal areas in places along the beach. Any changes in sand accumulation in intertidal sections of the beach is likely to be minimal in comparison with naturally occurring events. The sand to be deposited is less than 10% of the averaged long-term sediment transport along the coast. Thus, it is unlikely the proposed action has the potential to substantially modify, destroy or isolate an area of important habitat for migratory wading shorebirds.	Unlikely
11. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	
The proposed action is unlikely to result in invasive species becoming established in an area of important habitat for migratory seabirds. Implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species.	Unlikely
12. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	

Nesting and roosting habitat of wading shorebirds in predominantly above the high-water mark and beyond the area where indirect impacts are predicted to potentially occur as a result of this proposal. Impacts on foraging alone are likely to be minimal, short-term and very localised such that they are unlikely to seriously disrupt the lifecycle of any wading shorebird populations in the study area.	Unlikely	
Conclusion:	The proposal is unlikely to result in a significant impact on wading shorebirds considered as part of this assessment.	

Sea Turtles

Sea Turtles (these will be assessed as one group which includes all the species in the table below)

Scientific Name	Common Name	FM Act	BC Act	EPBC Act	Potential Impact
Chelonia mydas	Green Turtle		V	V, M	Boat Strike, nesting, foraging habitat quality, noise
Caretta caretta	Loggerhead Turtle		E	E, M	Boat Strike, nesting, foraging habitat quality, noise
Eretmochelys imbricata	Hawksbill Turtle			V, M	Boat Strike, foraging habitat quality, noise

A summary of migratory patterns and habitat use is provided in the table below

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
Chelonia mydas	Green Turtles can migrate more than 2600 km between their feeding and nesting grounds.	NA	In Australia, there are seven regional populations of Green Turtles that nest in different areas; the southern Great Barrier Reef (GBR), the northern GBR, the Coral Sea, the Gulf of Carpentaria, Western Australia's north-west shelf, the Ashmore and Cartier Reefs and Scott Reef. Nesting on the southern GBR and southern Queensland occurs between October and March (Limpus 2008a). Scattered nesting records occur along the NSW coast, including the Tweed Coast (DEE 2017). Turtle nesting in the Tweed can however occur as late as may and doesn't not typically occur before November.	Green Turtles spend their first five to ten years drifting on ocean currents. Once Green Turtles reach 30 to 40 cm curved carapace length, they settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds.
Caretta caretta	They move down the coast of eastern Australia with the East Australian Current, into the Tasman Front, past Lord Howe Island to the north of New Zealand and across the southern Pacific Ocean to the waters	Hatchlings enter the open ocean and begin feeding on small animals. Small Loggerhead Turtles live at or near the surface of the ocean and move with the ocean currents. In eastern Australia, there is evidence that they spend around 15 years or more in the open ocean, with much of their feeding in the top 5 m of water, before	In Australia, Loggerhead Turtles nest on open, sandy beaches in tropical regions. There is a nesting population known from the mainland coast of south-east Queensland. Low density and sporadic nesting also occur along the Sunshine Coast beaches and on the northern ends of Fraser, Moreton and North Stradbroke	Loggerhead Turtles are carnivorous, feeding primarily on benthic invertebrates in habitat ranging from nearshore to 55 m. They choose a wide variety of tidal and sub-tidal habitat as feeding areas

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
	off the coast of Peru and Chile.	recruiting to their chosen inshore or neritic feeding area.	Islands and southwards into northern NSW (DEE 2017), nesting of the southern QLD population typically occurs between October and March (Limpus 2008b). Turtle nesting in the Tweed can however occur as late as may and doesn't not typically occur before November.	
Eretmochelys imbricata	Pelagic and coastal species that may occupy coastal waters including estuaries but more common in warmer tropical waters of Queensland.		In Australia Hawksbill Turtles nest in WA, NT and northern QLD.	Hawksbill Turtles spend their first five to ten years drifting on ocean currents. Once Hawksbill Turtles reach 30 to 40 cm curved carapace length, they settle and forage in tropical tidal and sub-tidal coral and rocky reef habitat. They primarily feed on sponges and algae

5 Part Test

Sea turtles' listings under the BC Act

Green Turtle (*Chelonia mydas*): Vulnerable

Loggerhead Turtle (*Caretta caretta*): Endangered

(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The proposal has the potential to reduce habitat quality and result in interactions, which includes vessel strikes and disturbing turtles, while foraging or seeking refuge. In addition, both Green and Loggerhead turtles may nest occasionally and sporadically during summer months along adjacent beaches.

The proposal has the potential to reduce the quality of foraging habitat for turtles. The deposition of sediment may mobilise sediments, increase turbidity and reduce the ability of turtles to forage as effectively in the study area. Given that these turtles likely forage over a very large area (the study area likely constitutes only a very small portion of their foraging range) these impacts are likely to be minimal and restricted to small localised (approximately 50 m in radius) pulse events following the deposition of sediment. Potential impacts on nesting animals would likely be limited to individual turtles, localities and timings, and such events should be managed accordingly by the CEMP and monitored to ensure the proposal is not impacting on the nesting success of these individuals.

Any impacts on the local viable turtle population are considered to be minimal and restricted to short-term decreases in foraging habitat quality and potential disturbance of individual nesting turtles and interactions during the activity (which would be monitored and managed within the CEMP). Thus, it is unlikely that the proposed activity will have an adverse effect on the life cycles of any turtle species such that a viable local population is placed at risk of extinction.

(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

NA

(c) in relation to the habitat of a threatened species or ecological community: **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and** **(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and** **(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality**	
i.	The proposed works may alter the benthic habitat through increased sedimentation and reduced habitat quality with reduced water quality at the subject site due to increases in mobilised sediments. The proposal has the potential to reduce habitat quality and or modify foraging habitat for sea turtles. The deposition of sediment may mobilise sediments, increase turbidity and result in increased sedimentation of nearby reefs. However, plumes are predicted to be very localised and episodic, and the sand to be deposited is less than 10% of the averaged long-term sediment transport along the coast.
ii.	Changes in beach sediment composition and amounts may impact on nesting behaviour and success of turtles. Direct impacts from the amount and composition of sediment potentially transported will be restricted to subtidal areas; the conceptual sediment transfer model describes the area as currently having considerable variability in sand transport with a strong littoral transport to the north in shallow area (Jacobs 2017). Given this, potential changes in sediment composition in higher intertidal areas of the beach are likely to be minimal.
iii.	The habitat potentially modified by the proposal will be restricted to marginal foraging areas adjacent to the beach. Potential impacts will constitute localised and episodic disturbances, which are not expected to permanently restrict the access to or use of any habitat by turtles.
(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).	
NA	
(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process	
KTPs that are likely to be exacerbated by the proposed development include: • injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris • the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW These KTPs would be mitigated through on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site)	
Conclusion	It is recommended that the CEMP adopts practises that minimise the potential for and manage risks of impacts from interactions e.g. boat strike and disturbance of nesting turtles during operational works. Given implementation of these practices, the proposal is unlikely to result in a significant impact on the vulnerable and migratory, Hawksbill Turtle or Green Turtle, or the endangered and migratory Loggerhead Turtle populations in the locality.

Significance Impact Criteria

Sea turtles listed under the EPBC Act Green Turtle (*Chelonia mydas*): Vulnerable, Migratory Loggerhead Turtle (*Caretta caretta*): Endangered, Migratory Hawksbill Turtle (*Eretmochelys imbricate*): Vulnerable, Migratory	Likelihood
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
1. lead to a long-term decrease in the size of a population for endangered species, important population for vulnerable species	
The proposed activity has the potential to reduce foraging habitat quality and result in interactions, which includes vessel strikes and disturbing turtles while foraging or seeking refuge. In addition, both Green and Loggerhead turtles may nest occasionally and sporadically during summer months along adjacent beaches. Potential impacts on nesting is unlikely and limited to individual turtles, localities and timings. Potential impacts will not be constant but rather episodic disturbances, which are not expected to permanently restrict the access to or use of any foraging or nesting habitat for these species. Impacts from potential interactions during the activity will be mitigated through adoption of environmentally sound vessel practises as part of the CEMP. Thus, it is unlikely that the proposed activity will lead to a long-term decrease in the size of an important population of Loggerhead, Hawksbill, or Green turtles.	Unlikely
2. reduce the area of occupancy of an endangered species, important population for vulnerable species	
The area potentially impacted by the proposal will be very small in relation to the area of occupancy of turtles (which are wide-ranging) and will only result in a very short-term and localised decrease in the quality of potential foraging habitat.	Unlikely

Thus, the proposed action is not expected to impact on an important population of Loggerhead, Hawksbill, or Green turtles.	
3. fragment an existing population into two or more populations for an endangered or vulnerable species	
The area potentially impacted by the proposal will be restricted to areas adjacent to the beach. Potential impacts will not be constant but rather episodic disturbances, which are not expected to permanently restrict the access to or use of any foraging or nesting habitat. Thus, the proposed action will not fragment any populations of Loggerhead, Hawksbill, or Green turtles.	None
4. adversely affect habitat critical to the survival of a species	
Individual Green and Loggerhead Turtles occasionally and sporadically use the adjacent beach for nesting at times. Nesting is restricted to higher intertidal areas, where effects from potential changes in the composition and amount sediment from the proposal are unlikely. Thus, it is unlikely the proposed action will adversely affect habitat critical to the survival of Loggerhead, Hawksbill, or Green turtles.	Unlikely
5. disrupt the breeding cycle of a population	
Only Loggerhead and Green turtle are known to nest in the area. Nesting occurs occasionally and sporadically during summer months on higher areas on the adjacent beaches. Changes in beach sediment composition and amounts may impact on nesting behaviour and success of turtles. However, changes in sediment composition and amount from the proposal are unlikely to differ markedly from natural changes. Thus, the proposed action is unlikely to disrupt the breeding cycle of the population of Loggerhead or Green turtles in the area.	Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	
The amount of habitat with potential to be modified by the proposal will be very localised and any modifications will be short-term and restricted to a decrease in habitat quality. Thus, it is unlikely the habitat will be modified to the extent that the species is likely to decline.	Unlikely
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;	
The proposed action is unlikely to result in invasive species harmful to Loggerhead, Hawksbill, or Green turtles becoming established in habitat at the site. Implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species.	Unlikely
8. introduce disease that may cause the species to decline, or	
The proposed action is unlikely to result in the introduction of disease that may cause a decline of Loggerhead, Hawksbill, or Green turtles.	Unlikely
9. interfere substantially with the recovery of the species.	
The proposed action is unlikely to substantially interfere with the recovery of Loggerhead, Hawksbill, or Green turtles.	Unlikely
For listed migratory species	
10. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	
The area of habitat with potential to be modified by the proposal will be very localised and any modifications will be short-term and restricted to a decrease in foraging habitat quality. Thus, it is unlikely the proposed action would substantially modify, destroy or isolate an area of important habitat for migratory Loggerhead, Hawksbill, or Green turtles.	Unlikely
11. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	
The proposed action is unlikely to result in invasive species becoming established in an area of important habitat for Loggerhead, Hawksbill, or Green turtles. Implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species.	Unlikely
12. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	
Only Loggerhead and Green turtle are known to nest in the area. Nesting occurs occasionally and sporadically during summer months on higher areas on the adjacent beaches. Changes in beach sediment composition and amounts may impact on nesting behaviour and success of turtles. However, changes in sediment composition and amount from the proposal are unlikely to differ markedly from natural changes. Thus, the proposed action is unlikely to disrupt the breeding cycle of an ecologically significant proportion of the population of Loggerhead or Green turtles in the area..	Unlikely
Conclusion:	It is recommended that the CEMP adopts practises that minimise the potential for and manage risks of impacts from interactions e.g. boat strike and disturbance of nesting turtles during operational works. Given implementation of these practices, the proposal is unlikely to result in a significant impact on the vulnerable and migratory, Hawksbill Turtle or Green Turtle, or the endangered and migratory Loggerhead Turtle populations in the locality.

Marine Mammals

Marine Mammals (these will be assessed as one group which includes all the species in the table below).

Scientific Name	Common Name	FM Act	BC Act	EPBC Act	Potential Impact
Megaptera novaeangliae	Humpback Whale		V	V, M	Boat strike, refuge habitat quality
Tursiops aduncus	Spotted Bottlenose Dolphin			M	Boat strike, foraging habitat quality
Tursiops truncatus	Bottlenose Dolphin			M	Boat strike, nesting, foraging habitat quality

A summary of migratory patterns and habitat use is provided in the table below

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/ nesting	Foraging habitat
Megaptera novaeangliae	Migrates between Antarctica and the Great Barrier Reef between March and November. Widely distributed in coastal waters and may enter deep embayment's at times.		The breeding area for the eastern population of the Humpback Whale is presumed to be off the coast between central and northern Queensland. Albeit, anecdotal evidence of calving in areas further south as the population is growing is increasing.	Some feeding has been observed in Australia's coastal waters, but this is thought to primarily be opportunistic and forms only a small portion of their nutritional requirements.
Tursiops aduncus	Movement patterns in Australia and south Africa are variable, and include year-round residency in small areas, long-range movements and migration.		Calving peaks occur in spring and summer or spring and autumn.	Indian Ocean Bottlenose Dolphins from eastern Australia, South Africa and eastern Africa feed on a variety of fish and cephalopods, but in specific areas a few species may dominate the diet.
Tursiops truncatus	Bottlenose Dolphins inhabiting high latitudes may exhibit seasonal migration.		In several non-Australian populations calving is known to peak in spring and summer or spring and autumn.	Inshore Bottlenose Dolphins feed mainly on a variety of fish and invertebrates from both the littoral and sub-littoral zones, while offshore animals feed primarily on mesopelagic fish and oceanic squids.

5 Part Test

Marine mammals listed under the BC Act

Humpback Whale (*Megaptera novaeangliae*): Vulnerable

(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The proposal has the potential to reduce habitat quality and result in interactions with Humpback Whales during the migratory season that may disturb and injure individuals. In addition, there is also potential that some whales may calve in the area, although the site is not recognised as an important calving place for the species. Any impacts on Humpback Whale habitat will be minimal and, in most part, restricted to relatively small and localised increases in turbidity and sedimentation during deposition events. Interactions with the species may include vessel strikes and disturbing animals seeking refuge. The potential for interactions will be managed through controls (such as stopping works if whales present; establishing minimum buffer distance between any whale and vessels, reporting any whale sightings/near misses to the project manager) as stipulated within the CEMP.

Thus, it is considered unlikely that the proposed activity will have an adverse effect on the life cycles of the species such that the East Coast Population of Humpback Whales is placed at risk of extinction.

(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

NA

(c) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality

i. The proposed works may reduce the quality of the habitat (through increased turbidity and/or sedimentation) which Humpback Whales may pass through and/or use during the migration season. However, these alterations will be short-term and very localised and unlikely to affect Humpback Whales.

ii. The area impacted by the proposal will be restricted to areas adjacent to the beach. Potential impacts will not be constant but rather short-term episodic disturbances, which is not expected to permanently restrict the access to or use of any habitat by Humpback Whales.

iii. The habitat that will potentially be subject to increased turbidity/sedimentation is in very shallow water adjacent to the beach. These animals generally do not spend long periods in these areas and prefer to forage in more open, deeper water and only occupy these areas for relatively short periods of time. As such the areas to be impacted are considered unlikely to be important to long-term survival of Humpback Whales during their migration.

(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).

NA

(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process

KTPs that are likely to be exacerbated by the proposed development include:

- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
- the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW

These KTPs would be mitigated through on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site)

Conclusion

It is recommended that the CEMP adopts practises that minimise the potential for and manage risks of impacts from interactions e.g. boat strike and disturbance of any whales taking refuge during operational works during the migration season.

The proposal is considered unlikely to result in significant impacts to the Humpback Whale population that migrates past and at times through the study area.

Significance Impact Criteria

Marine mammals listed under the EPBC Act	
Humpback Whale (*Megaptera novaeangliae*): Vulnerable, Migratory	Likelihood
Spotted Bottlenose Dolphin (*Tursiops aduncus*): Migratory	
Bottlenose Dolphin (*Tursiops truncatus*): Migratory	
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	

1. lead to a long-term decrease in the size of a population for endangered species, important population for vulnerable species	
The study area is likely to be used by a number of migratory marine mammal species. These include Humpback Whales which migrate past this area, and dolphins that may forage throughout the subject site. Impacts on migratory marine mammals include potential for vessel strike, interactions and a reduction in the quality of foraging habitat (through increased turbidity and sedimentation). Given that these species are likely to forage over an area much greater than the study area, potential impacts on foraging are unlikely. Potential impacts from interactions with vessels and vessel strikes can be minimised through the adoption of thorough environmental practises into the CEMP (such as stopping works if whales present; establishing minimum buffer distances from animal, reporting any sightings/near misses to the project manager). Thus, it is considered unlikely the proposed action will lead to a long-term decrease in the size of an important population of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely
2. reduce the area of occupancy of an endangered species, important population for vulnerable species	
The area to be potentially impacted will be very localised and any changes to habitat quality of marine mammals would be short-term. Thus, it is unlikely the proposed action will impact on an important population of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely
3. fragment an existing population into two or more populations for an endangered or vulnerable species	
The area impacted by the proposed action will be restricted to areas adjacent to the beach, while impacts will not be constant but rather localised and episodic disturbances, which will not permanently restrict the access to or use of any habitat. Thus, the proposed action will not fragment an important population of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	None
4. adversely affect habitat critical to the survival of a species	
The area affected by the proposed action is not recognised as critical to foraging or breeding habitat of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	None
5. disrupt the breeding cycle of a population	
There is potential for migratory marine mammals to calve in the area. Evidence of increasing calving during migration by Humpback Whales in areas further south, includes areas on the Tweed Coast. However, the study area is not recognised as a significant area for calving for migratory marine mammals and any disturbances will be very short-term and localised. Potential impacts from interactions with vessels and vessel strikes will be minimised through the adoption of thorough environmental practises into the CEMP (such as stopping works if whales present; establishing minimum buffer distances from animal, reporting any sightings/near misses to the project manager). Thus, it is unlikely the proposed action will disrupt the breeding cycle of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	
The proposal may reduce the quality of foraging habitat at times due to poorer water quality from the mobilisation of sediments. Given that migratory marine mammals forage over very large areas, it is unlikely that the quality of the habitat will decrease to the extent that the species are likely to decline.	Unlikely
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;	
The proposal is unlikely to result in invasive species harmful to migratory marine mammals becoming established in the study area.	Unlikely
8. introduce disease that may cause the species to decline, or	
The proposed action is unlikely to result in the introduction of disease that may cause a decline of migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely
9. interfere substantially with the recovery of the species.	
The proposed action is unlikely to substantially interfere with the recovery of any migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely
For listed migratory species	
10. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	
The proposal may reduce the quality of foraging habitat at times due to poorer water quality from the mobilisation of sediments. Given that migratory marine mammals forage over very large areas, it is unlikely the proposed action would substantially modify an area of important habitat for migratory Humpback Whales, Spotted Bottlenose and Bottlenose Dolphins.	Unlikely

11. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	
The proposed action is unlikely to result in invasive species becoming established in an area of important habitat for Humpback Whales, Bottlenose Dolphins or Spotted Bottlenose Dolphins.	Unlikely
12. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	
There is potential that migratory marine mammals may calve in the area. Evidence of increasing calving during migration by Humpback Whales in areas further south, includes areas on the Tweed Coast. However, the subject site is not recognised as a significant area for calving by migratory marine mammals and any disturbances will be short-term and localised. Potential impacts from interactions with vessels and vessel strikes will be minimised through the adoption of thorough environmental practises into the CEMP (such as stopping works if whales present; establishing minimum buffer distances from animal, reporting any sightings/near misses to the project manager). Migratory marine mammals are likely to forage in the area at times, however these species forage over areas much greater than the study area, thus, potential impacts on foraging are likely to be minimal. During migration marine mammals are likely to utilise habitat in the area, however the proposal is not expected to interfere with the much wider migratory routes of these marine mammal species. Thus, it is unlikely the proposed action will disrupt the breeding cycle of any migratory marine mammal populations.	Unlikely
Conclusion:	It is recommended that the CEMP adopts practises that minimise the potential for and manage risks of impacts from interactions e.g. boat strike and disturbance of any whales/cetaceans taking refuge during operational works during the migration season. The proposal is considered unlikely to result in a significant impact to the vulnerable and migratory Humpback Whale or migratory Bottlenose and Spotted Bottlenose dolphins that migrates past and at times through the study area. .

Reef fish and sharks

Fish and sharks associated with adjacent reef habitat (these will be assessed as one group which includes all the species in the table below).

Scientific Name	Common Name	FM Act	BC Act	EPBC Act	Potential Impact
Carcharius taurus	Grey Nurse Shark	CE		E	Foraging habitat
Epinephelus daemelii	Black Rockcod	V		V	Foraging habitat

A summary of migratory patterns and habitat use is provided in the table below

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/spawning	Foraging habitat
Carcharius taurus	Grey Nurse Sharks migrate between aggregation sites. In NSW, tagged sharks have been recorded moving over 800 km between sites in relatively short periods of time, and show site fidelity by returning to the same sites in consecutive years.	Grey Nurse Sharks are found predominantly in inshore coastal waters. They have been recorded at various depths but spend most of their time in waters less than 40 m in depth. On some occasions, individual sharks swim to deeper depths. The deepest depth recorded in NSW DPI tracking of Grey Nurse Sharks is 232 m. Grey Nurse Sharks congregate at a number of sites along the coast of NSW and southern Queensland. These sites have rocky reef with gravel or sand filled gutters,	Mating occurs in spring, and pregnant females migrate north to southern Queensland where they spend about 6 months at aggregation sites away from sexually mature males.	The species is active during the day and at night, and feeds on a wide range of bony fishes, small sharks and rays.

Scientific Name	Migratory patters	Roosting/refuge habitat	Breeding/spawning	Foraging habitat
		overhangs or caves and are termed aggregation sites.		
Epinephelus daemelii	NA	Adult Black Rockcod are usually found in caves, gutters and beneath bommies on rocky reefs, from near shore environments to depths of at least 50 m. They are territorial and normally will occupy a particular cave for life.	The Black Rockcod is a protogynous hermaphrodite, first developing as a sexually mature female and then changing into a male later in life at a length of approximately 100 – 110 cm. Time of spawning is unknown. Following spawning larvae complete the pelagic, drifting larval stage and are often found in coastal rock pools. Slightly older juvenile black cod are often found in estuary systems	Black Rockcod are epibenthic predators feeding on macroinvertebrates (mainly crustaceans) and fishes on or near the bottom. Adults will prey on larger fish. They are considered to be most active at dusk and during the night (Kuiter 1996) and are thought to feed during these times.

Seven Part Test

Reef fish and sharks listed under the FM Act

Grey Nurse Shark (*Carcharius Taurus*): Critically Endangered

Black Rockccod (*Epinephelus daemelii*): Vulnerable

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

These species likely reside in areas of the reef with complex topography and high rugoisty. Impacted habitat from the proposed action is likely to be restricted to marginal foraging habitat across sand flats, which these species may visit at dusk and during the night to find prey. The proposal area includes only a small amount of this habitat in the vicinity of the potential foraging range of these species. As such they are unlikely to be dependent on the foraging habitat within the proposal area for survival. Thus, the proposed action is unlikely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

NA

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

ii. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

NA

d) In relation to the habitat of a threatened species, population or ecological community:

i. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

ii. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

i. The proposal has potential to impact on the quality of marginal foraging habitat over adjacent soft sediments that these species may use at times. Overall, modification of this habitat will be minimal, and modifications will likely be restricted to short-term decreases in benthic productivity, availability of prey items and smaller epibenthic foraging fish species that are likely to be prey for these larger predatory species.
ii. The proposed action is unlikely to isolate or fragment the area of foraging habitat used by this species.
iii. The habitat within the study area is likely constitutes marginal foraging habitat only for these species and of minimal importance to the long-term survival of the species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No areas of Critical habitat have been identified for Black Rockcod.
Cook Island and its associated reefs have not been listed as critical habitat for Grey Nurse Sharks.

f) Whether the action proposed is consistent with the objectives or actions of a Recovery Plan or Threat Abatement Plan

The proposal is consistent with objectives or actions of a Recovery Plan or Threat Abatement Plans for these species.
It remains important to ensure water quality does not impact reef habitat important to these species within the Aquatic Reserve.

g) Whether the action proposed constitutes or is part of a Key Threatening Process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP

NO

Conclusion	Impacted habitat from this proposal is likely to be confined to soft sediment habitat, which may be used for foraging at times. The proposal area includes only a small amount of this habitat in the vicinity of the potential foraging range of these species. As such they are unlikely to be dependent on the foraging habitat within the proposal area for survival. No shelter or breeding habitat for these species will be affected. Therefore, potential impacts on Black Rockcod and Grey Nurse Sharks that may utilise soft sediment habitat around Cook Island are considered unlikely to be significant

Significance Impact Criteria

Reef fish and sharks listed under the EPBC Act Grey Nurse Shark (*Carcharius Taurus*): Endangered Black Rockccod (Epinephelus daemelii): Vulnerable	Likelihood
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
1. lead to a long-term decrease in the size of a population for endangered species, important population for vulnerable species	
Impacts from the proposed action are confined to those on marginal foraging habitat over adjacent areas of soft sediment, which Grey Nurse Sharks and Black Rockcod may use at times. The proposal area includes only a small amount of this habitat in the vicinity of the potential foraging range of these species. As such they are unlikely to be dependent on the foraging habitat within the proposal area for survival and the proposal is unlikely to lead to a long-term decrease in the size of a population of these species.	Unlikely
2. reduce the area of occupancy of an endangered species, important population for vulnerable species	
Impacts from the proposed action are confined to those on marginal foraging habitat over adjacent areas of soft sediment. Shelter and breeding habitat such as nearby reefs that Grey Nurse Sharks and Black Rockcod occupy are not likely to be impacted by the proposal.	Unlikely
3. fragment an existing population into two or more populations for an endangered or vulnerable species	
The proposal will not fragment any habitat used by these species.	None
4. adversely affect habitat critical to the survival of a species	
No areas of Critical habitat have been identified for Black Rockcod. Cook Island and its associated reefs have not been listed as critical habitat for Grey Nurse Sharks.	None
5. disrupt the breeding cycle of a population	
Likely impacts are confined to marginal foraging habitat for these species only. No breeding or shelter habitat for these species will be impacted. It is unlikely the proposed action will impact on the breeding cycle of these species.	Unlikely
6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	

Impacts from the proposed action are confined to those on marginal foraging habitat over adjacent areas of soft sediment, which Grey Nurse Sharks and Black Rockcod may use at times. The proposal area includes only a small amount of this habitat in the vicinity of the potential foraging range of these species. As such they are unlikely to be dependent on the foraging habitat within the proposal area for survival. Thus, it is unlikely that the proposed action will modify the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely
7. result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;	
There is minimal potential for invasive species to establish in the proposal area. Implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species.	Unlikely
8. introduce disease that may cause the species to decline, or	
There is minimal potential for invasive species to establish in the proposal area. As mentioned above, implementation of on-site management (e.g. waste disposal and cleaning equipment before mobilisation to site) will assist in minimising the risk of introduction of invasive species.	Unlikely
9. interfere substantially with the recovery of the species.	
Likely impacts are confined to marginal foraging habitat for these species only. There is minimal potential to interfere substantially with the recovery of the species.	Unlikely
For listed migratory species	
10. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	
NA	
11. result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or	
NA	
12. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	
NA	
Conclusion:	Impacted habitat from the proposed action is likely to be confined to soft sediment habitat, which may be used for foraging at times. There is minimal potential for impacts on Black Rockcod and Grey Nurse Sharks that may utilise soft sediment habitat around Cook Island and no shelter or breeding habitat will be affected. As such significant impacts to these species are considered unlikely.

niche
Environment and Heritage

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box 2443 North Parramatta NSW 1750
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Appendix F
Tweed quantified conceptual sediment transport model

JACOBS

Tweed Quantified Conceptual Sediment Transport Model

TWEEDSAND BYPASSING

IH123200-3200-RPT-1001 | 2

20 December 2017

Tweed Conceptual Sediment Transport Model

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Jacobs Australia Pty Limited

32 Cordelia Street
PO Box 3848
South Brisbane QLD 4101 Australia
T +61 7 3026 7100
F +61 7 3026 7300
www.jacobs.com

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0	28/09/2017	Draft for Client Review	JJ	SW	SW
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2	20/12/2017	Final	JJ	SW	SW

Contents

1. Introduction

1.1 Background

The Tweed River Entrance Sand Bypassing Project (TRESBP), now referred to as Tweed Sand Bypassing (TSB), is a joint initiative of the New South Wales and Queensland governments that has the dual objectives of

- Establishing and maintaining a navigable depth at the Tweed River Entrance; and
- Achieving and maintaining a continuing supply of sand to southern Gold Coast beaches at a rate that is consistent with the natural littoral drift.

The sand bypassing system aims to meet these objectives in perpetuity by pumping of sand slurry via a jetty mounted pumping system at Letitia Spit and dredging of the Tweed River entrance area. The sand bypassing system has been fully operational since 2001.

The TSB has adopted a 2015-2024 Project Strategy. A priority of the Project Strategy over the next five years (2017-2021) is the rapid growth in knowledge and understanding of the TSB's operating environment and its interrelationships with and effects on coastal processes. The knowledge building is achieved through development and ongoing operation of a so-called Sand Transport Information System (STIS). The STIS seeks to build the knowledge through a series of work packages. This report presents the outcomes of work package STIS001 of the STIS.

Figure 1-1 Locality map of STIS Project Area

1.2 Study Scope

The scope of this study involves the following task components:

- Based on existing available information held by TSB, synthesise and describe the current understanding of the geomorphic processes
- Develop a series of quantified conceptual models that depict and describe the key pathways and mechanisms for sand transport through the STIS Project Area
- Identify the critical knowledge gaps that exist in the current understanding of the sediment transport processes operating within the STIS, including the effects of TSB's sand bypassing operations, and recommend methodologies to fill these knowledge gaps

This report was prepared by Jacobs with the understanding that this is primarily a document for internal use by the TSB organisation. It has been assumed that the reader has a level of knowledge of coastal dynamics, the TSB operations and the STIS Project Area in general.

1.3 Historical Data and Reports

There is a considerable amount of monitoring data, relevant previous investigations and reports relating to the sediment transport processes in the Project Area (Refer to Figure 1-1) and in the region generally. Information reviewed and considered in this study includes:

- Previous technical reports and papers (as referenced)
- Hydrographic surveys conducted regularly by TSB
- Wave time-series data obtained from the Tweed River and Point Lookout wave buoys
- Dredge and sand pumping logs
- Historical aerial photographs
- Historical photographs
- Sediment budget analysis data
- Streamflow data from the Tweed River streamflow gauge at Uki

As part of the study Jacobs has compiled a reference register, which describes the nature and aspects covered in key information sources considered in this study and provides details on the time parcel and geomorphic compartment it relates to.

2. Coastal Processes

2.1 General Considerations

Coastal processes essentially involve the movement of water (eg. waves and currents) and sediment (mostly sand) within and around the coastal zone. Sediment dynamics includes sand transport (1) within the mostly dry sandy beaches, (2) in the intertidal swash zone, and (3) in the deeper nearshore waters, and can be both alongshore transport (parallel to the shoreline) and cross shore transport (in the direction of wave travel, often more or less perpendicular to the shoreline).

Coastal processes are influenced by:

- **Regional geology,** which sets the structure of the coastal zone.
- **Local geomorphology**, which is affected by and affects other coastal processes, but particularly in the case of the Tweed River entrance area, has been significantly modified by human intervention, including the operation of the TSB.
- **Waves**, generated offshore (swell) and locally during storms, including variability in the wave climate over seasonal, inter-annual and decadal time scales.
- **Ocean water levels**, generated from tides and amplified during storms.
- **Nearshore currents**, generated by the combined effect of breaking waves, winds, tides and regional oceanic processes.
- **Coastal Entrance Dynamics**, which in the case of the Tweed River may contribute to currents around the entrance relating to tides and catchment flows
- **Wind**, which can generate wind driven (Aeolian) sediment transport

The natural coastal processes influencing the supply and movement of sand through the STIS Project Area are complex. The coastline is exposed to a moderate to high wave climate with significant seasonal variability. Consequently, the coastal zone across the STIS Project Area is highly dynamic. The mechanism of sand bypassing around the Tweed River entrance and around Point Danger is extremely complex due to the intricate interaction of numerous oceanic and estuarine processes that are of significance there.

This section of the report provides a description of the key coastal processes affecting the STIS project area, synthesised from previous studies and existing data.

2.2 Geology and Geomorphology of the STIS Project Area

The STIS Project Area consists of the coastal zone between Fingal Head in New South Wales and Currumbin in Queensland. It includes approximately 13 km of shoreline, comprising a number of sandy beaches controlled by the rocky headlands and offshore islands (Fingal Head, Point Danger, Snapper Rocks, Elephant Rock, Currumbin Rock and Cook Island), the Tweed River entrance and a number of groyne structures (Kirra Point groyne, Miles Street groyne, Currumbin groyne).

Regionally, the Project Area is part of a long coastal unit that experiences a continuous northerly alongshore transport of sand extending from around the Clarence River in the south to Moreton Bay in the north. This coastal unit has a series of major controlling headlands past which the sand is moved by the prevailing waves.

The beaches as we see them today result from the morphological evolution of the continental shelf and coastline predominantly during the late Quaternary period covering two epochs, most notably:

- The late Pleistocene covering the last 120,000 years including the last ice age; and

- The Holocene covering the past 10,000 years of the most recent warmer post-glacial period.

During the late Pleistocene, mean sea levels fell to reach a level of about 120m below the present level during the peak of the last ice age (about 18,000 years ago). From 18,000 to 6,000 years ago, sea levels rose back quickly to around present levels.

During the latter part of that sea level rise, sand was brought from the continental shelf to the coastal zone, forming dunes seaward of the former residual Pleistocene barriers. These Holocene dune barriers have subsequently evolved under the influence of contemporary coastal processes. While it is generally considered (Thom 1975; Thom 1984; Stephens et al 1981) that the most recent Holocene period of sand supply to the coast essentially ended about 3,000 years ago, it has been suggested that there remains a small but relatively significant shoreward supply within the coastal unit (Roy et al 1997; Cowell et al 2000; Roy 2001; Goodwin et al 2005, Patterson, 2013). Based on modelling of the coastline evolution processes, Patterson (2013) estimated that there remains a net shoreward supply of sand to the beach system from the lower shore-face along most of the regional coastline between the Clarence River and the Gold Coast of about 1-2m^3/m/year.

Thom et al (1978) suggest that 7,000 years ago mean sea levels were somewhere between 10m and 15m below present and, at this sea level, Cook Island and Fingal Head were acting as littoral barriers along the coastline. The Tweed River would have exited to the sea via Wommin Lake. Letitia Spit, because of the Fingal Head littoral barrier, would probably not be completely developed at that time.

The attainment of present day sea levels, approximately 6,000 years ago, would have drowned these land bridges between existing outcrops of bedrock. The Cudgen to Fingal sand barrier would have moved onshore to occupy, more or less, the present shoreline position. The location of the Tweed River at Wommin Lake would have no longer been stable due to the high longshore sediment flux. The river mouth would have migrated sequentially northwards. The high influx of sediment would have led to the development of Letitia Spit (Refer Figure 2-1).

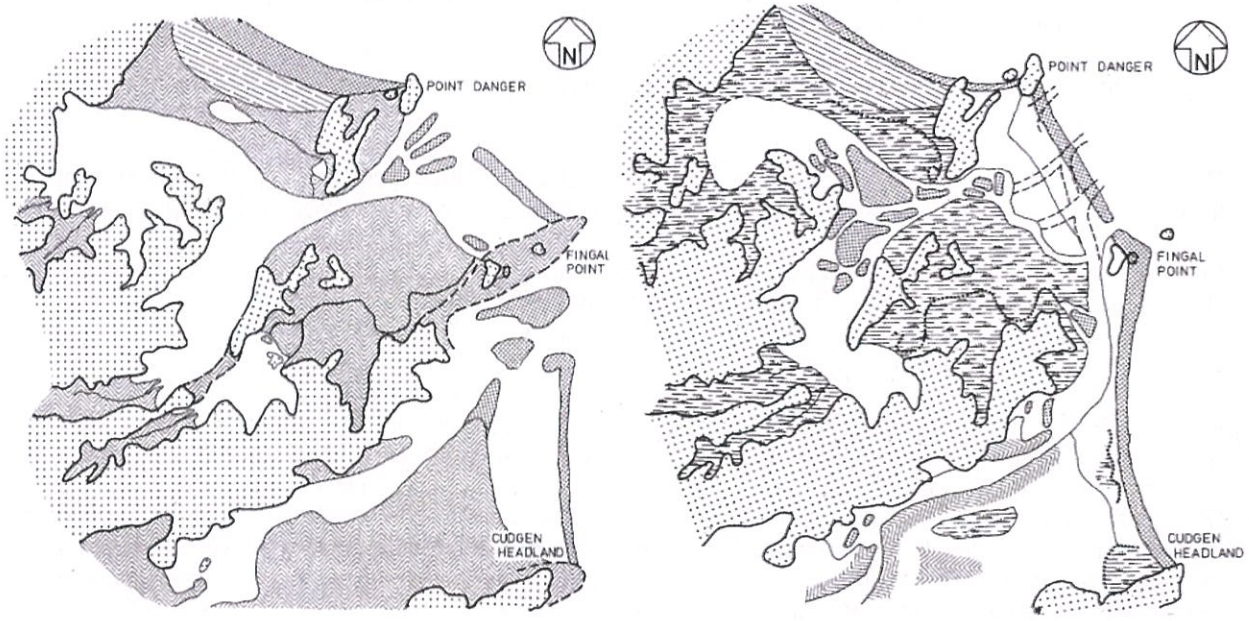

Figure 2-1 Tweed Area Coastal Geomorphology Circa 7000 Years before present (left) and 6000 years before present (right) [Druery and Curedale, 1979]

The northward migration of the Tweed River entrance would have induced a sympathetic migration of the lower reach of Terranora Creek. It is considered that Ukerebagh Passage represents a former Creek course, abandoned during some stage of northward migration. Tidal reworking of sediments within the Terranora estuary would have led to the formation of tidal bay shoals at Boyd's Bay and at the main entrance to the Broadwaters (Druery and Curedale, 1979).

It is important to recognise that the present day entrance to the Tweed River is a relatively recent event in geological terms and there is uncertainty whether or not the reworking of marine sediments within the estuary may still have been an ongoing process, even without human interventions.

The behaviour of the lower Gold Coast shoreline during those processes was extremely complex, affected substantially by the groyne effect of the Fingal reef barrier to alongshore supply at somewhat lower sea levels, with subsequent high resupply as that barrier was submerged by the rising sea (Patterson, 2013). The result was substantial initial shoreline recession into the former Pleistocene barrier as sea levels fell and redevelopment of the wide Holocene barrier evident today along Bilinga-Tugun, Palm Beach, Burleigh and north from Mermaid Beach around 8,000 to 5,000 years ago (BMT WBM, 2017).

Since the late 19th century, the coastline has seen substantial change as a result of human activities. Human activities in the Project Area include construction of river training walls, groynes, seawall, sand mining, sand supply as beach nourishment and sand relocation activities, including operation of the TSB's sand bypassing system. For a detailed timeline of these human activities, reference should be made to BMT WBM (2017).

2.3 Natural Sand Transport Mechanisms

Sand is transported through the STIS Project Area by the combined action of waves, currents and wind within the context of shoreline shape, alignment and bathymetry. Waves have three key effects on sand transport in the nearshore zone, namely:

- **Wave Breaking** - As waves break they generate radiation stresses, which may drive longshore currents (particularly within and immediately outside the surfzone);
- **Wave Motion** – The waves' orbital motion may impose shear stresses on the seabed, which may mobilise and put into suspension the seabed sediment. The asymmetry of wave orbital motion in shallower water causes a differential in the forcing on the bed sediments that is stronger towards the shoreline, resulting in an onshore mass transport of sand; and
- **Undertow** - Waves can cause a bottom return current and rip currents in the surfzone which can result in cross-shore transport.

Currents generated by waves, tide, wind and the East Australian Current provide the primary mechanism for the transport of the sand that has been mobilised and put into suspension by wave/current action.

In simple terms, sand transport at a typical beach location may be regarded as involving longshore and cross-shore sand movement processes. These act concurrently and interact together.

2.3.1 Longshore Sand Transport

Waves approaching the shoreline from an oblique angle generate a current alongshore which, in conjunction with the wave action, transports sediment. Depending on the prevailing wave direction, the alongshore sediment transport may be directed either north or south along the coast. On the northern NSW and south-east Queensland beaches, the net alongshore sediment transport is directed to the north, due to the predominant south easterly wave climate relative to the general north to south orientation of the coastline. The rate of longshore transport tends to be the highest during the summer and early autumn months, as during these months wave energy levels are typically the highest.

Alongshore sediment transport (also commonly referred to as littoral drift) occurs predominantly in the mid to outer surfzone (or inner nearshore zone), diminishing in strength with distance offshore into deeper water. In some circumstances, winds, tides and the East Australian Current may also contribute to longshore currents, and may dominate the currents outside of the surfzone.

Along the majority of the Project Area, the wave-driven alongshore current is the dominant current with respect to overall sediment transport regime along the coastline. As a result, along most locations, the majority of the longshore sand transport occurs in water depths of less than 4 metres. Notwithstanding this, wind-driven

currents and the East Australian Current have a significant influence on the longshore transport regime in the deeper parts of Point Danger, Duranbah and Letitia Spit, particularly in water depths of greater than 8 metres.

Wave effects on longshore transport are complex due to the variability of wave conditions, the dependency on the ever-changing beach profile geometry and the complex effects of headlands, man-made structures and coastal inlets on both the waves itself and the wave-driven currents.

2.3.2 Cross shore Sand Transport

Sand is transported across the nearshore beach profile by wave action. Cross-shore sand transport may be in the offshore direction during beach erosion events or onshore during normal swell conditions. Transport in these two directions appears to occur in distinct modes, with quite disparate time scales.

Onshore sediment transport essentially takes place along the direction of wave propagation, and occurs typically in "wave-like" motions whereby ripples are formed and individual packets of sand move towards (and merge onto) the dry beach. Onshore transport is largely related to the effects of waves. Outside the breaker zone, the wave crests become increasingly higher and of shorter duration than the troughs as waves approach the coast and enter shallower water. As a result, the orbital velocity becomes increasingly asymmetrical, leading to a net sand transport in the direction of wave propagation. The effect of gravity (through the bed slope) opposes this tendency for onshore movement of sand.

Within the breaker zone, the breaking of waves drives an onshore-directed mass transport which is concentrated around the water surface. The onshore-directed mass transport induces an offshore-directed return flow which is concentrated near the bottom of the water column. This so-called undertow is relatively strong in magnitude and located in an area in close proximity to the seabed, where sediment loads are typically the highest. The undertow can be substantial during storms, and can carry a considerable amount of suspended sediment offshore.

Rip currents are strong, localised seaward directed currents that are generated by longshore variations in wave setup. Rip currents tend to occur wherever there is variability in bathymetry or around structures, likes groynes and training walls. These lateral escape currents are usually quite narrow, but can become more common, wider and faster when breaking waves are large and powerful. High offshore-directed flows in rip currents can be a hazard for swimmers and can transport significant amounts of sand offshore.

2.4 Wave Climate

The regional wave climate is a dominant factor in the coastal processes affecting the Project Area. The deep-water wave climate of the northern NSW / southern Queensland coast comprises a highly variable wind wave climate superimposed on a persistent long period, moderate to high energy south to south-easterly swell.

Typically, the swell offshore may range up to 3-4m significant wave height with periods in the range 7 to 15 seconds. Prevailing wind waves are incident from a wider range of directions, consistent with the wind climate for the region, and range from small short period local 'sea' conditions to large storm and cyclone waves in excess of 6-7m significant wave height.

As part of the TRESBP, a directional wave recording buoy was established offshore from Letitia Spit in 20-30m of water depth, which has recorded local wave conditions since January 1995.

Table 2-1 and Table 2-2 present wave parameter statistics, based on wave recordings during the period between March 1995 and March 2017. Table 2-1 shows the frequency of occurrence FOR NOT in terms of significant wave height and peak wave direction, and Table 2-2 in terms of significant wave height and spectral peak wave period.

In addition, wave measurement data from an offshore location near Point Lookout (Brisbane Offshore) was sourced from the Queensland Department of Science, Information Technology and Innovation. Basic wave parameter statistics for this location, derived from wave recordings during the period between March 1997 and March 2017, are presented in Table 2-3 and Table 2-4.

The ambient wave climate tables illustrate the predominance of the southeasterly offshore wave direction, meaning that most of the time (>80% of time) waves approach the Tweed Heads wave buoy from a downcoast direction. Modal wave heights at the Tweed Heads wave buoy are 0.5-2.0m with spectral peak periods predominantly (~65%) in the range 7-12 seconds.

Table 2-1 and Table 2-2 show that waves with a significant wave height in excess of 7.5m have been observed at the Tweed Heads wave recorder. The highest recorded (hourly) significant wave height at Tweed Heads during the 22 year monitoring period was 7.52m and was recorded on 3rd May 1996. During the May 1996 event, large north-easterly waves were experienced for a 4-day period with the recorded significant wave height exceeding 5m for a period of approximately 28 hours (See also Figure 2-2). The maximum wave height recorded during this event was 13.1m.

There is seasonal variability in the wave climate with the summer and autumn months being the most energetic. Large wave events (events with a maximum significant wave height of greater than 5m) predominantly occur during the summer and autumn months, and rarely occur during spring or winter. During the winter months, the wave climate is mostly influenced by swell. Consequently, the average peak wave period is larger during these months and the energy-weighted wave direction is more southerly (ie. moved in a clockwise direction), compared to the other seasons.

Table 2-1 Wave Height and Direction Occurrence Frequency – Tweed Heads Wave Buoy (%)

		Peak Wave Direction (degrees TN)																		
		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	
Hs (m)		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	TOTAL
0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.3%	0.2%	0.0%	0.0%	0.0%		0.0%	1.2%
0.5	1	0.0%	0.1%	0.6%	1.1%	1.0%	0.7%	1.1%	2.0%	3.8%	5.7%	6.2%	6.5%	4.8%	1.3%	0.1%	0.0%	0.0%	0.0%	35.0%
1	1.5	0.0%	0.1%	0.7%	1.2%	0.8%	0.5%	1.4%	3.8%	6.4%	7.3%	6.5%	6.4%	4.7%	1.4%	0.1%	0.0%	0.0%	0.0%	41.3%
1.5	2	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.6%	2.1%	2.8%	2.8%	2.5%	2.2%	1.4%	0.3%	0.0%				15.2%
2	2.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.8%	1.0%	1.1%	0.8%	0.6%	0.2%	0.0%	0.0%			0.0%	5.0%
2.5	3			0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.4%	0.3%	0.2%	0.1%	0.0%	0.0%					1.4%
3	3.5					0.0%	0.0%	0.1%	0.2%	0.2%	0.1%	0.0%	0.0%							0.6%
3.5	4					0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%								0.2%
4	4.5					0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%								0.1%
4.5	5						0.0%	0.0%	0.0%	0.0%	0.0%									0.1%
5	5.5					0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									0.0%
5.5	6						0.0%	0.0%	0.0%	0.0%										0.0%
6	6.5						0.0%	0.0%	0.0%											0.0%
6.5	7						0.0%	0.0%	0.0%											0.0%
7	7.5							0.0%	0.0%											0.0%
	>7.5							0.0%												0.0%
	Grand T	0.0%	0.3%	1.4%	2.4%	1.9%	1.5%	3.8%	9.5%	14.8%	17.5%	16.4%	16.0%	11.3%	3.0%	0.2%	0.0%	0.0%	0.0%	100%

Table 2-2 Wave Height and Peak Period Occurrence Frequency – Tweed Heads Wave Buoy (%)

		Peak Wave Period (s)																			
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Hs (m)		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21 >21	TOTAL
0	0.5	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%
0.5	1	0.0%	0.4%	1.6%	2.4%	3.1%	4.3%	4.6%	5.3%	5.5%	3.2%	2.6%	1.1%	0.5%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	35.0%
1	1.5		0.0%	0.8%	2.4%	3.5%	5.8%	6.7%	6.5%	6.8%	3.9%	2.9%	1.2%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	41.3%
1.5	2			0.0%	0.2%	0.9%	2.0%	3.0%	2.9%	2.6%	1.6%	1.2%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%		0.0%	15.2%
2	2.5				0.0%	0.1%	0.4%	0.9%	1.0%	1.0%	0.6%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%			5.0%
2.5	3					0.0%	0.1%	0.2%	0.3%	0.4%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%				1.4%
3	3.5						0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%					0.6%
3.5	4							0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%					0.2%
4	4.5							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%							0.1%
4.5	5								0.0%	0.0%	0.0%	0.0%	0.0%	0.0%							0.1%
5	5.5								0.0%	0.0%	0.0%	0.0%	0.0%	0.0%							0.0%
5.5	6								0.0%	0.0%	0.0%	0.0%	0.0%								0.0%
6	6.5									0.0%	0.0%	0.0%	0.0%								0.0%
6.5	7										0.0%	0.0%	0.0%								0.0%
7	7.5										0.0%	0.0%	0.0%								0.0%
	>7.5											0.0%									0.0%
	TOTAL	0.0%	0.4%	2.4%	5.0%	7.6%	12.7%	15.7%	16.3%	16.8%	9.9%	7.8%	3.1%	1.4%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	100%

Table 2-3 Wave Height and Direction Occurrence Frequency – Brisbane Offshore Wave Buoy (%)

		Peak Wave Direction (degrees TN)																
Hs (m)		N	NNE	NE	WNE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									0.1%
0.5	1	0.5%	0.7%	0.6%	1.5%	3.0%	3.8%	4.6%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.7%
1	1.5	1.3%	1.2%	0.8%	4.4%	7.4%	6.6%	10.2%	2.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	35.0%
1.5	2	0.5%	0.3%	0.2%	2.9%	5.2%	4.6%	7.8%	2.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	24.6%
2	2.5	0.1%	0.0%	0.1%	1.3%	2.5%	2.6%	4.8%	2.3%	0.1%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	13.7%
2.5	3	0.0%	0.0%	0.0%	0.5%	1.1%	1.1%	2.2%	1.2%	0.0%							0.0%	6.2%
3	3.5	0.0%		0.0%	0.2%	0.4%	0.4%	1.0%	0.6%	0.0%		0.0%						2.7%
3.5	4			0.0%	0.1%	0.2%	0.2%	0.4%	0.2%	0.0%								1.1%
4	4.5			0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.0%				0.0%				0.5%
4.5	5			0.0%	0.0%	0.1%	0.0%	0.0%	0.0%									0.2%
5	5.5			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									0.1%
5.5	6			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									0.0%
6	6.5			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									0.0%
6.5	7			0.0%	0.0%	0.0%	0.0%	0.0%										0.0%
	>7.0			0.0%		0.0%	0.0%							0.0%				0.0%
	TOTAL	2.5%	2.2%	1.8%	11.1%	20.1%	19.6%	31.1%	11.0%	0.3%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	100%

Table 2-4 Wave Height and Peak Period Occurrence Frequency – Brisbane Offshore Wave Buoy (%)

		Peak Wave Period (s)																			
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Hs (m)		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21 >21	TOTAL
0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%					0.1%
0.5	1	0.0%	0.3%	0.7%	0.9%	1.1%	2.0%	2.4%	2.5%	2.2%	1.2%	1.3%	0.7%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	15.7%
1	1.5		0.1%	1.1%	2.5%	2.3%	4.5%	6.4%	6.1%	5.2%	2.8%	2.3%	1.1%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%		35.0%
1.5	2		0.0%	0.1%	1.1%	2.0%	3.2%	4.6%	4.3%	4.0%	2.3%	1.8%	0.9%	0.4%	0.1%	0.0%	0.0%	0.0%			24.6%
2	2.5				0.1%	0.9%	2.2%	2.8%	2.5%	2.1%	1.3%	1.1%	0.5%	0.2%	0.0%	0.0%	0.0%				13.7%
2.5	3				0.0%	0.1%	0.8%	1.4%	1.3%	1.0%	0.7%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%				6.2%
3	3.5				0.0%	0.0%	0.1%	0.6%	0.6%	0.5%	0.4%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%				2.7%
3.5	4					0.0%	0.0%	0.1%	0.2%	0.3%	0.2%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%				1.1%
4	4.5						0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%					0.5%
4.5	5						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					0.2%
5	5.5							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						0.1%
5.5	6							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						0.0%
6	6.5								0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						0.0%
6.5	7								0.0%	0.0%	0.0%	0.0%									0.0%
	>7.0									0.0%	0.0%	0.0%									0.0%
	TOTAL	0.0%	0.4%	1.8%	4.6%	6.5%	12.9%	18.3%	17.6%	15.5%	9.0%	7.6%	3.7%	1.6%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	100%

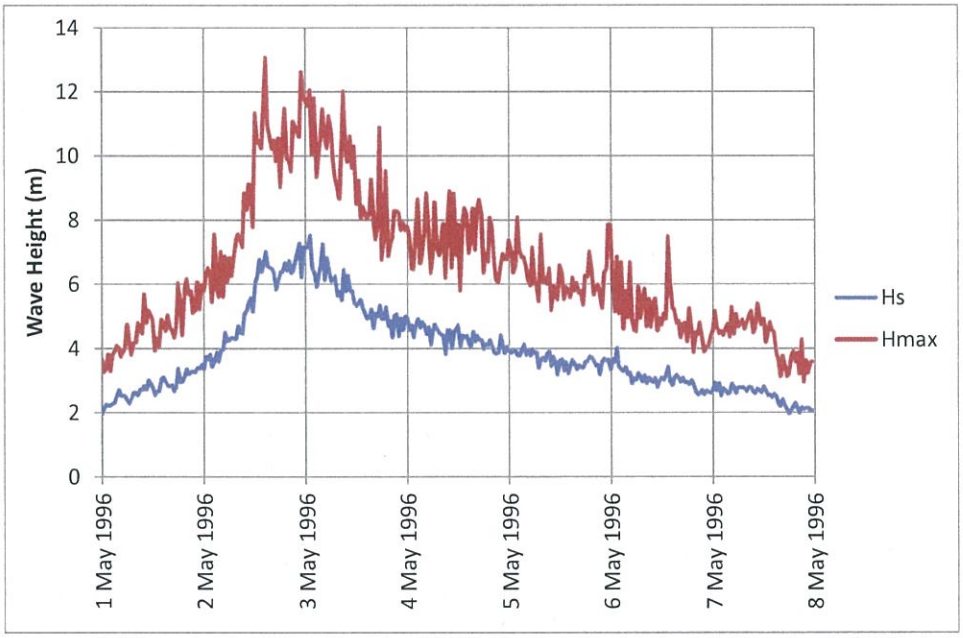

Figure 2-2 Recorded Wave Height during the May 1996 event

2.5 Currents

Nearshore currents are important because of their significant influence on longshore sand transport. The nearshore current regime within the Project Area is controlled by a complex interaction of meteorological conditions, tides, shelf/ocean currents and waves. In general terms, the following factors contribute to the generation of the overall current pattern in the Project Area:

- breaking waves,
- winds,
- tides; and
- the East Australian Current.

The relative influence of each of these components will vary throughout the study area and is strongly influenced by the water depth and the proximity of bathymetric features such as reefs, headlands, islands and river entrances.

2.5.1 Wave-driven currents

Wave-driven longshore currents are generated when waves break in front of the shoreline under an angle. The speed and nature of the longshore current is dependent on the height and angle of the breaking wave together with the bathymetric features.

Under most conditions, the speed of the wave-driven longshore current along the STIS shoreline is up to about 1m/s, either upcoast or downcoast depending on the wave angle and occurs in a zone of up to about 2-3 metres water depth (Hyder et al., 1997). During storms, larger longshore currents may be generated, with flow velocities up to about 1.5-2.0m/s may occur out to depths of about 8-10m along the open beaches. Adjacent to headlands (Point Danger) and around structures (notably the Tweed River training walls) even higher flow velocities may be expected to occur locally.

2.5.2 Wind-induced currents

As wind blows over the water surface, they exert stresses on the water surface, which may not only generate waves but can also drive shore-parallel currents.

Measurements of the currents at a location off Point Danger, at about 8m water depth (HaskoningDHV, 2017)) indicate that under ambient conditions wind typically generates a nearshore current of about 0.2m/s at this location. It is expected that during storms, larger currents will be generated, probably in the order of up to about 0.5m/s along most of the coastline.

2.5.3 Tidal Currents

The tide in the STIS region is classified as semi diurnal with significant diurnal inequalities, with two high tides and two low tides per day that are generally at different levels (i.e. the two high tide levels are different in any one day).

The tidal wave propagates more or less east to west, with little longshore components except the north facing beaches between Point Danger and Coolangatta. In most of the Project Area, tidal currents are generally of low speed (<0.1 m/s) except within the direct zone of influence of the Tweed River entrance.

The nature and magnitude of the tidal currents over the entrance bar depends on the bar bathymetry which changes continuously. Generally, the tidal current pattern at the entrance bar is radial inflow over a large part of the entrance during the flooding tide and a concentrated ebb jet directed seaward during the ebbing tide. The ebb jet may be deflected to the north or south under the influence of winds, waves, the East Australian Current and the local bar/channel configuration. Ebb flow velocities are typically about 1.0-1.5m/s through the entrance

and may reach up to about 1.5m/s over the entrance bar during larger spring tides (Hyder et al, 1997, Helyer et al., 2011).

Flood tide currents tend to enter the river more or less radially and consequently peak flow velocities over the bar during flood tides are substantially lower than the peak flow velocities during ebbing. Peak flood flow velocities over the bar will be dependent on the configuration of the entrance bar. Measurements in 2009 and 2010 by Helyer et al. (2011) when the entrance was relatively open suggest that peak flood flow velocities on the entrance bar may remain below 0.3m/s. In a more silted configuration, with a fully developed bar across the entrance, peak flood flow velocities over the bar will be significantly higher.

2.5.4 East Australian Current

The East Australian Current (EAC) has a significant influence on the nearshore currents in the study area, particularly outside the surfzone along the NSW shoreline (ie. Point Danger, the Tweed River entrance, Lititia Spit and Fingal).

Flow measurements (Helyer et al., 2011, HaskoningDHV, 2017) indicate that in the nearshore off Point Danger, at depths of greater 6m, there is a general southeasterly nearshore flow with a typical flow velocity of 0.3-0.4m/s. The headland at Point Danger tends to deflect the current, and generate clockwise circulation cells within the Letitia embayment. These circulation cells may in turn interact with tidal currents from the Tweed River entrance, and influence the sand transport around the jetty and river training walls.

2.6 Sediment Budget and Longshore Sediment Supply

Sand volume changes and longshore sand transport processes within the study region have been investigated in considerable detail over the past 40-50 years. Previous investigations include: Delft Hydraulics (1970), Roelvink & Murray (1992), Hyder et al. (1997), Patterson (1999), BMT WBM (2011, 2013, 2016, 2017).

These investigations indicate that there is a continuous northerly alongshore transport of sand. The latest Long Term Average (LTA) sediment transport analysis report (BMT WBM, 2016) suggests that the long term average net sand transport rate within the Project Area is about 550,000 m^3 per year. This study also highlighted that during the period 1995 to 2015 the average net transport of sand into the system by longshore transport past Fingal has on average been about 71,000 m^3 per year higher than the sand outflow rate at Currumbin (574,000m^3/year vs. 503,000m^3/year).

Recent sediment budget analyses by BMT WBM (2017) indicate that the system has gained approximately 9.2M m^3 of additional sand since 1962 of which approximately 6.2M m^3 can be attributed to beach nourishment activities at Kirra during the 1980s and 1990s. This leaves approximately 3.0M m^3 of additional sand, equivalent to an average rate of 56,000m^3/year, that cannot be attributed to the direct effects of man-made sand imports into the system. The vast majority of the sand volume gain has occurred within the littoral zone of the beaches to north of the Kirra Point groyne (notably North Kirra and Bilinga), and the ebb delta and lower estuary of the Tweed River.

There is substantial annual variability in the inflow of sand past Fingal. Littoral transport modelling by BMT WBM (2016) suggests that the net annual sediment transport rate past Fingal has varied between 1995 and 2015 between about 300,000m^3 (in 2014) and about 1,000,000m^3 (in 2004). This differs from the sediment transport regime out of the system at Currumbin, which shows much less annual variability.

Sand transport past Fingal Head occurs primarily through periodic sand 'slugs'. Sand from Dreamtime Beach will only travel around the headland when significant quantities of sand accumulate around the headland and substantial southerly waves occur. When these sand slugs move around the headland, these pulses of sand manifest themselves as substantial sand waves that eventually attach to the beach. Figure 2-3 presents an example of the progression of such sand slug around Fingal Head in May 2016.

Figure 2-3 Sand slug evident at southern part of Letitia Spit in May 2016

3. Quantified Conceptual Sediment Transport Model

3.1 Introduction

A series of quantified conceptual sediment transport models have been developed based on the synthesis of previous investigations and existing datasets. The conceptual sediment transport models present the key mechanisms and pathways for sand transport through the geomorphic compartments of the STIS Project Area.

According to their coastal process environment and geomorphic features, the Project Area has been divided into seven coastal compartments. The spatial extent of each compartment is shown in Figure 3-1. The offshore boundary of all compartments is the -20mAHD depth contour, beyond which it is expected that there would be no significant sand movement.

Features of each compartment are outlined in Table 3-1 below:

Table 3-1 STIS Project Area Coastal (Geomorphic) Compartment Overview

Compartment Name	Key features
Letitia Spit & Fingal Head	This compartment extends from the northern end of Dreamtime Beach to the southern Tweed River training wall, and includes Letitia Spit, a 3.6km long east-north-east facing beach. The TSB sand bypassing jetty is located approximately 220m south of the training wall, at a location where the Tweed River entrance bar merges into the littoral zone of Letitia Spit.
Tweed River entrance	This compartment includes, the entrance to the Tweed River, the Tweed River entrance bar and Duranbah beach.
Tweed Estuary	This compartment comprises the lower Tweed River estuary. It includes the river channel between the training walls, the main Tweed River channel system and the tidal broadwaters of Terranora and Cobaki, as far as it morphologically interacts with the other compartments of the STIS Project Area.
Point Danger to Snapper Rocks	The compartment extends from Point Danger to Snapper Rocks. It contains the Snapper Rocks East outlet, the primary discharge location for sand pumped by the TSB bypassing jetty.
Coolangatta-Kirra Embayment	This compartment extends from Snapper Rock to Tugun, and includes the beaches of Little Marley's, Rainbow Bay, Coolangatta, Kirra, North Kirra and Billinga. The sand transport regime through this compartment is a mixture of littoral transport and cross-embayment sand transport outside the littoral zone.
Tugun & Currumbin	This compartment is the most northern unit and extends from Billinga to the Currumbin Rock groyne in the north.

To assist with the development of the conceptual sediment transport models, the main sediment transport mechanisms and pathways under a range of key environmental conditions have been identified and assessed. The environmental conditions assessed are summarised in Table 3-2. Sediment transport mechanisms and pathways are presented graphically in Figure 3-2 to Figure 3-6, and described in detail in the sections below as appropriate.

Table 3-2 Description of Environmental Conditions

Scenario Name	Description
Modal SE Swell	This scenario represents the predominant ambient wave conditions at the site, comprising of waves with a significant wave height approximately in the range of approximately 0.5 to 2m and an offshore peak direction from the south easterly directional sector
SE Storm Event	This scenario represents a typical storm condition where waves would be typically greater than a significant wave height of 3m and come from a south easterly direction.
Typical NE Wave	This scenario represents a condition that is reasonably common during spring when local winds generate northeasterly waves. Peak wave periods of this scenario are typically in the range of 4 to 7 seconds and a significant wave height in the range of approximately 0.5 to 1.5m.
NE Storm Event	This scenario represents a storm condition where substantial waves come from the north east. These storms are relatively infrequent and often associated with a tropical cyclone or East Coast Low.
Catchment Flood Event	This scenario represents the conditions during a major catchment flood event.

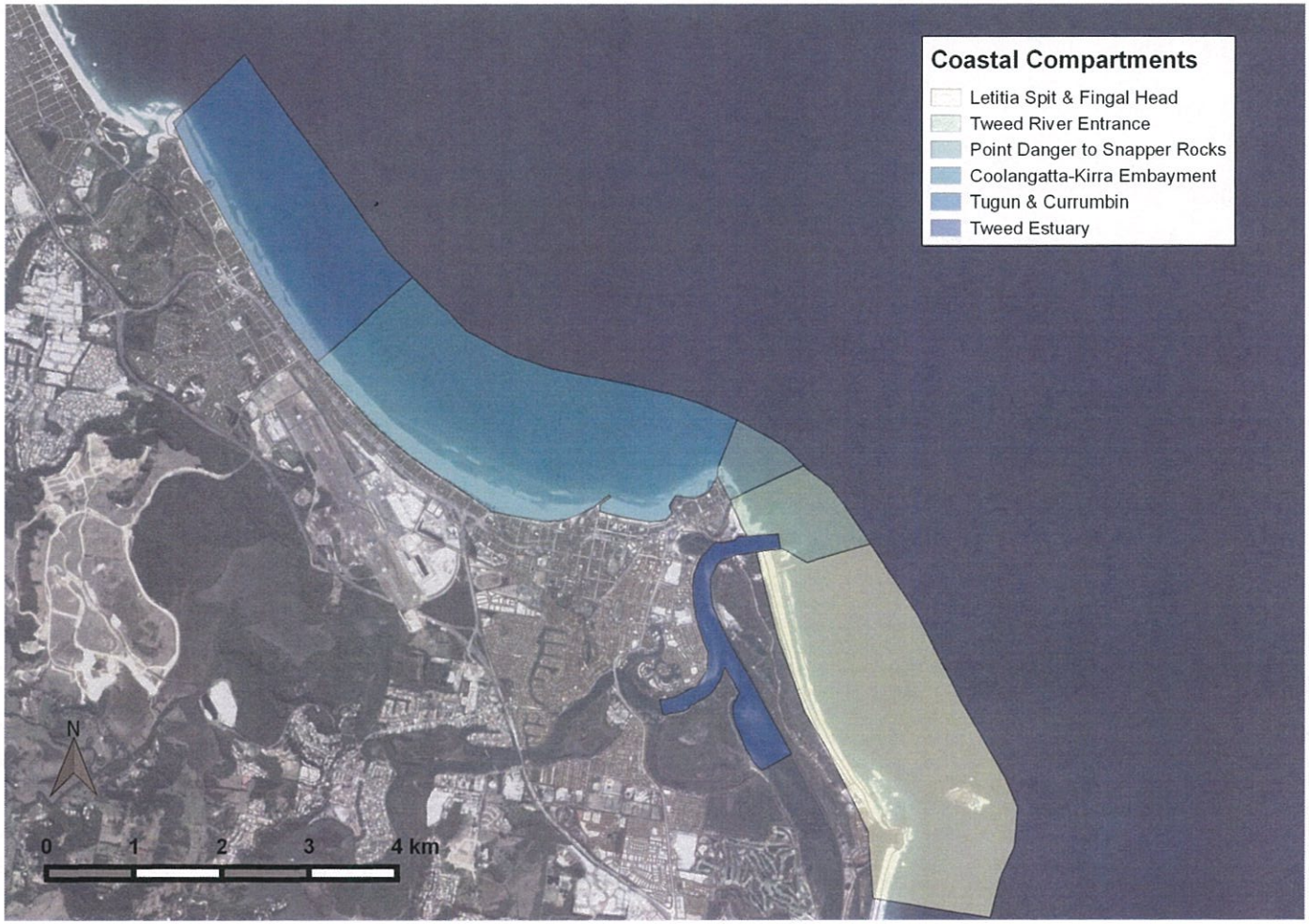

Figure 3-1 Geomorphic compartments of the STIS Project Area

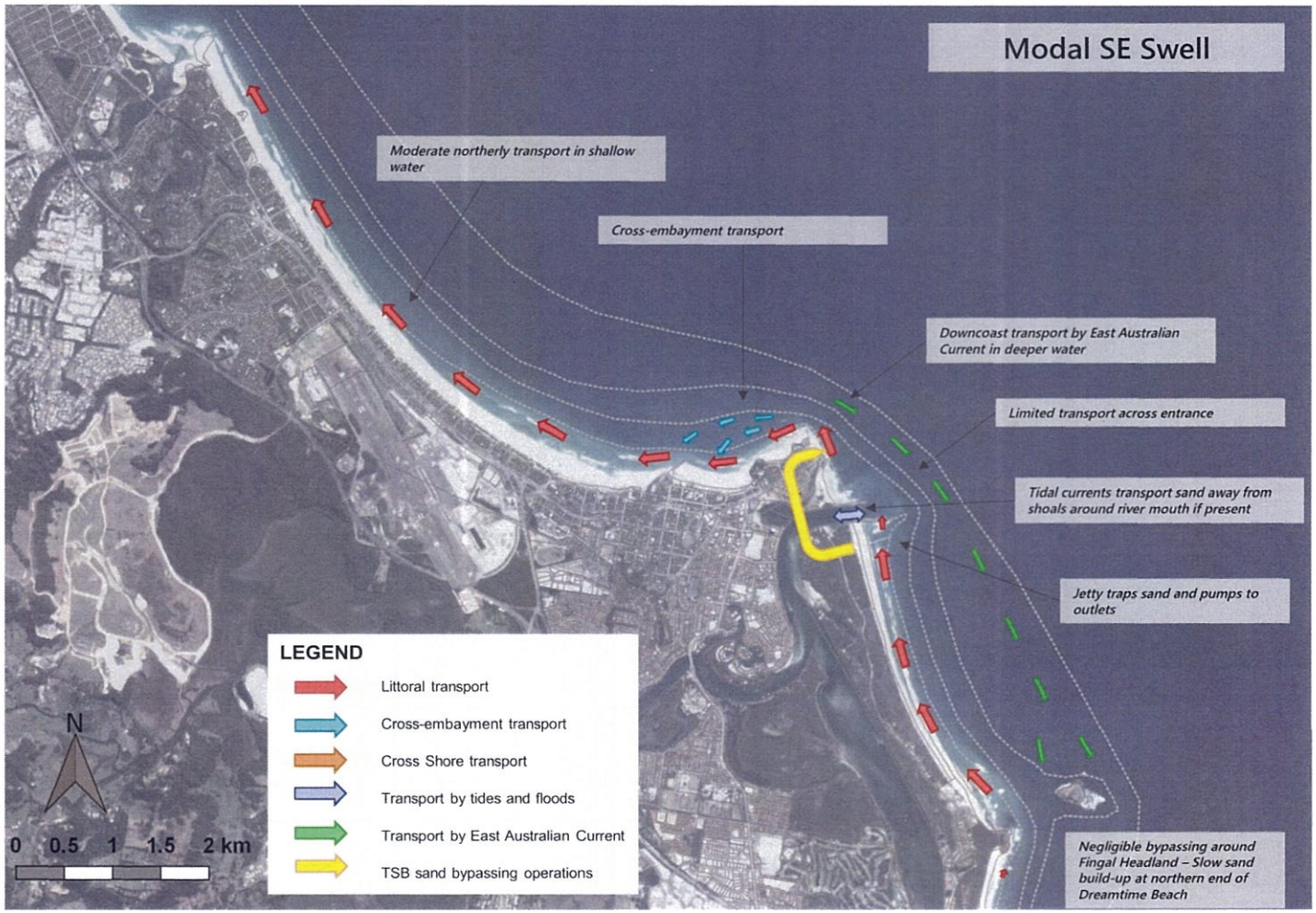

Figure 3-2 Main sediment transport mechanisms and pathways - 'Modal SE Swell' scenario

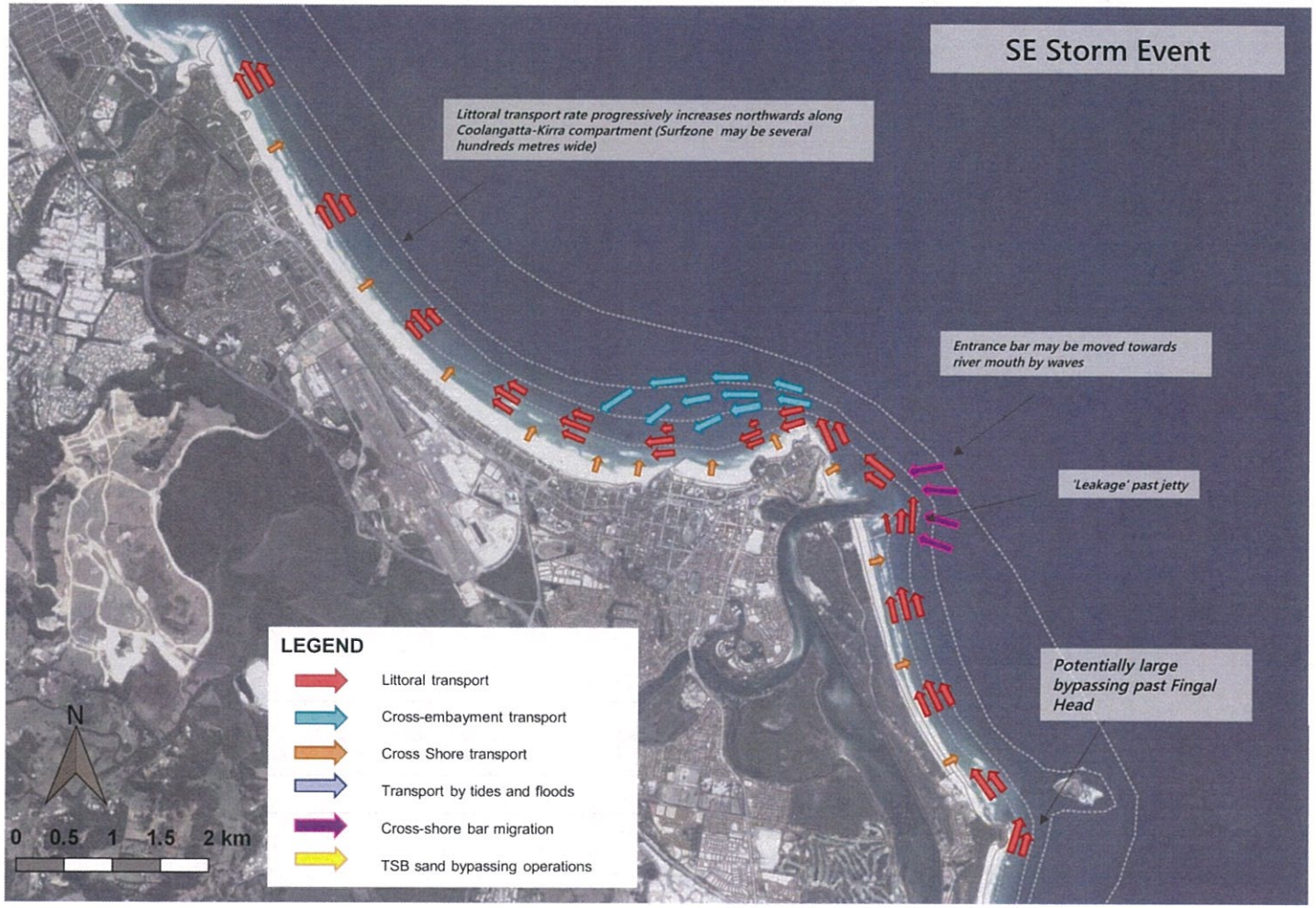

Figure 3-3 Main sediment transport mechanisms and pathways - 'SE Storm waves' scenario

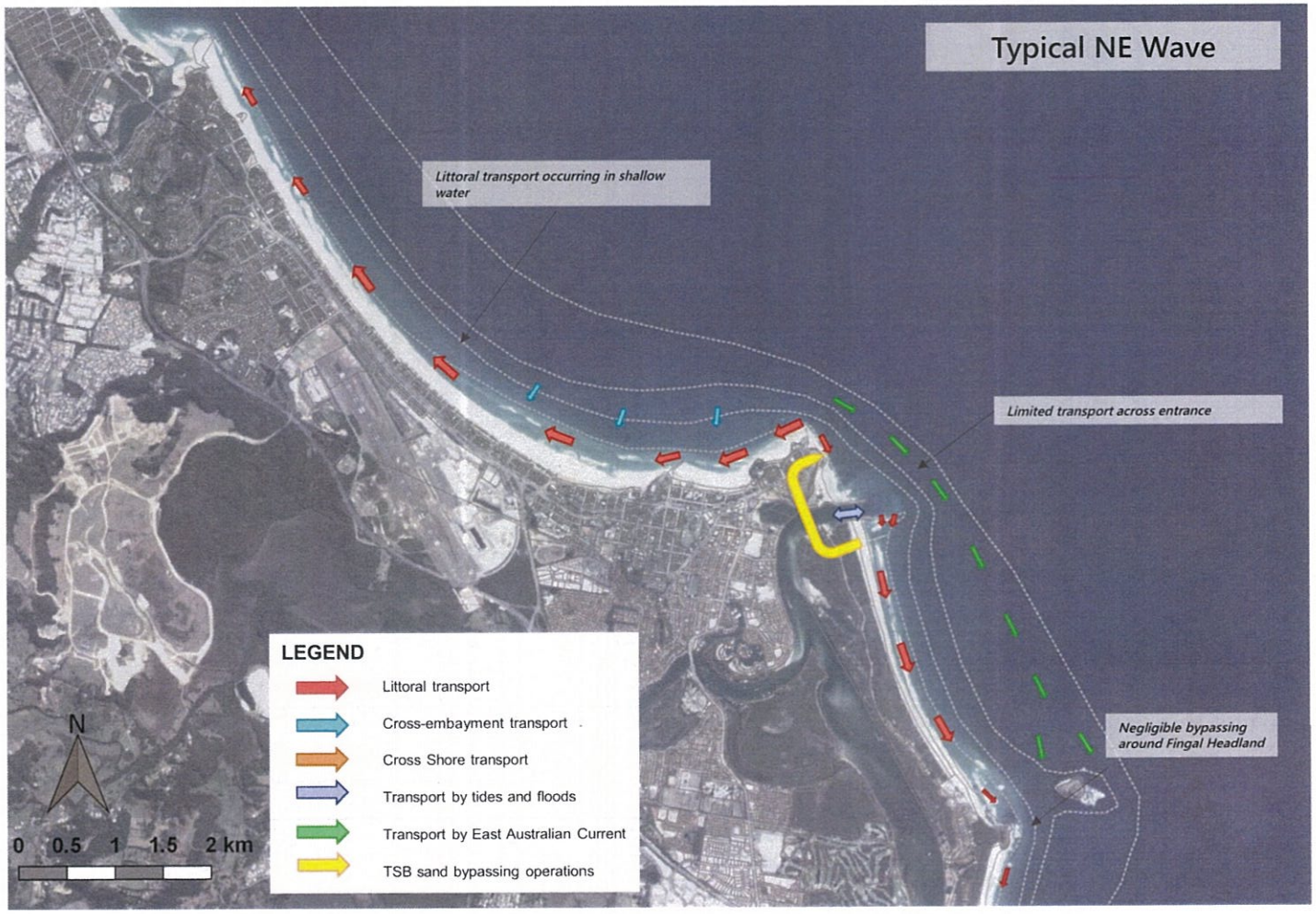

Figure 3-4 Main sediment transport mechanisms and pathways - 'Typical NE Wave scenario

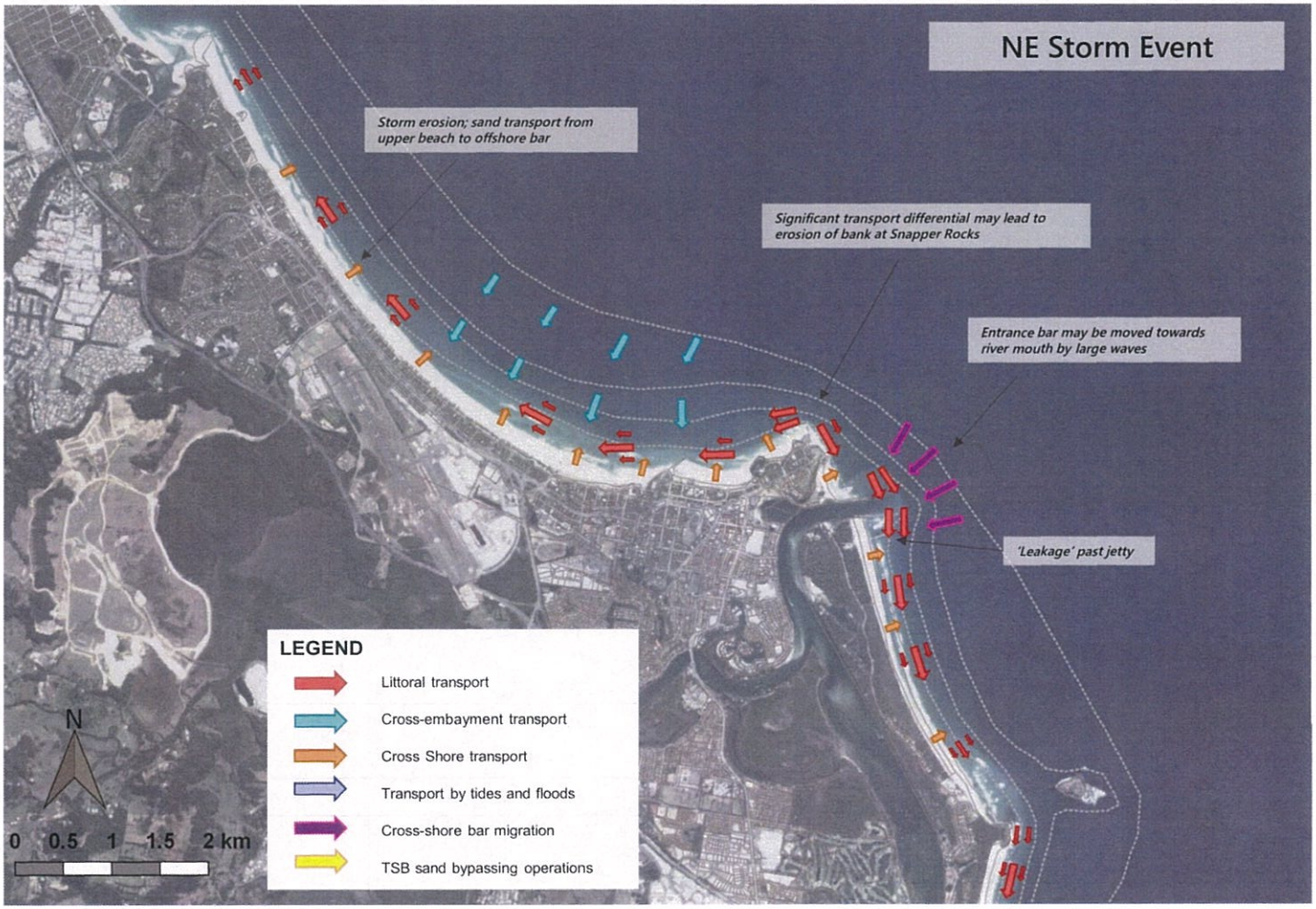

Figure 3-5 Main sediment transport mechanisms and pathways - 'NE Storm waves' scenario

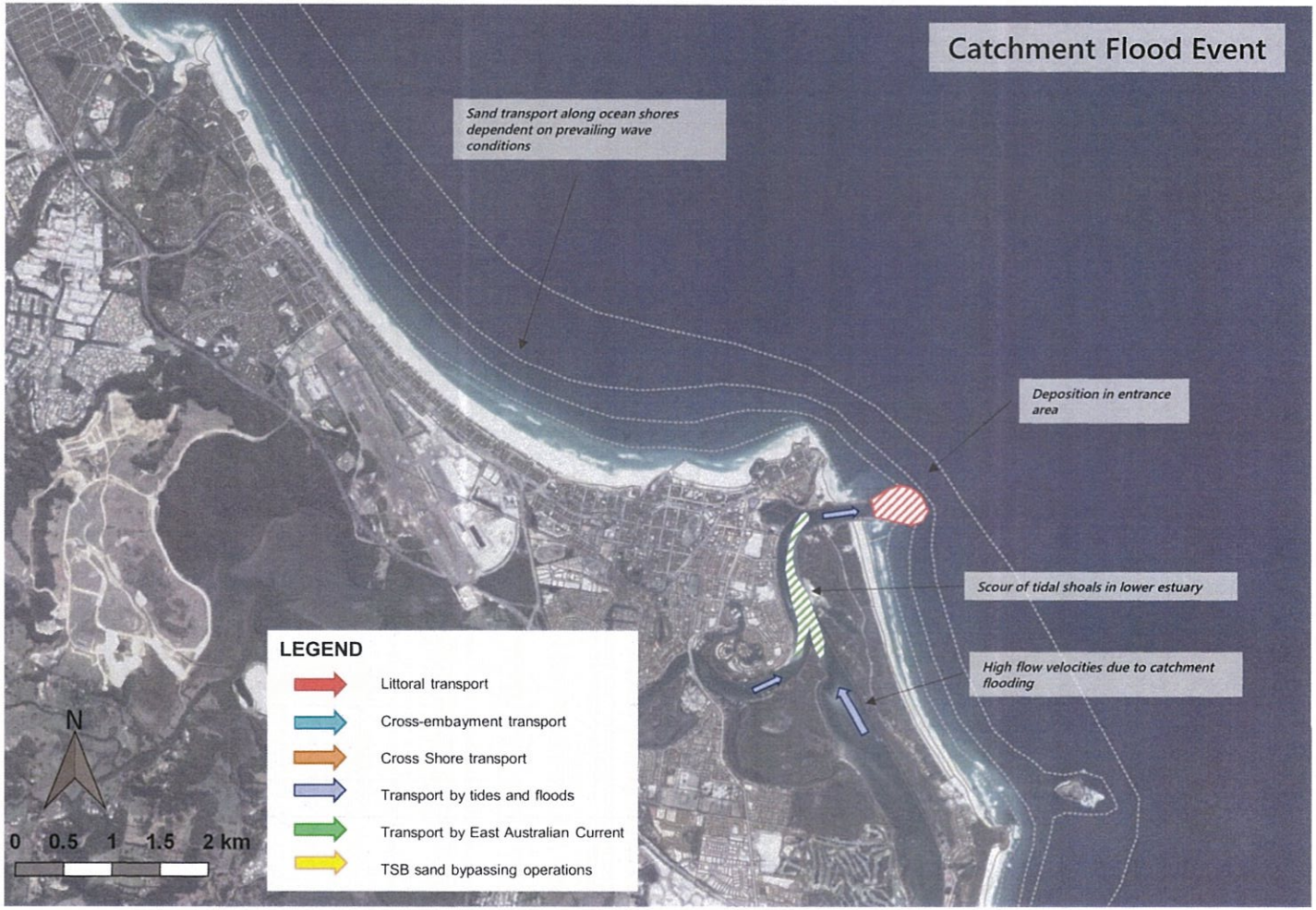

Figure 3-6 Main sediment transport mechanisms and pathways - 'Catchment Flood event' conditions

3.2 Letitia Spit & Fingal Head

Sand supply to Letitia Spit occurs past Fingal Head and tends to occur mostly as episodic 'slugs' of relatively large quantities of sand over a short period of time.

The periods of strong sand transport past the headland are usually associated with storm events with high waves, and will only occur when significant quantities of sand have accumulated at the northern end of Dreamtime Beach and are available to be carried around the headland by littoral transport processes. When prevailing waves cause a persistent sand transport away from the headland on both sides (ie. southward on the southern beach and northward to the north), the area immediately south and east of the headland tends to become eroded and bed rock may become exposed throughout the littoral zone of the northern end of Dreamtime Beach. When this occurs, sand transport past the headland can only resume if sufficient sand has returned to the southern side of the headland. As a result, there is considerable variability in the annual sand transport past Fingal Head. The average sand transport into Letitia Spit has been approximately 574,000 m^3 per year during the period 1995 and 2015, with annual lows of approximately 300,000m^3 and highs of above 1,000,000m^3/year (BMT WBM, 2016).

The sand transport pathway past the headland is expected to be exclusively located between Cook Island and Fingal Head. It is likely that some of the sand that is moved into the deeper parts between Fingal Head and Cook Island will be swept back into the Dreamtime Beach embayment by the East Australian Current, particularly if the sand slug extends onto the reefs around Cook Island where the East Australian Current frequently generates southeasterly currents above 0.5m/s (Helyer et al., 2011, Wyllie and Tomlinson, 1991).

On the southern end of Letitia Spit, sand movement generally manifests itself as sand waves that eventually attach to the beach. Often, these sand waves extend about one kilometre past the headland before becoming fully attached and can reach depths of about 8m, as illustrated by the bulge evident in the 2003 profile in Figure 3-7.

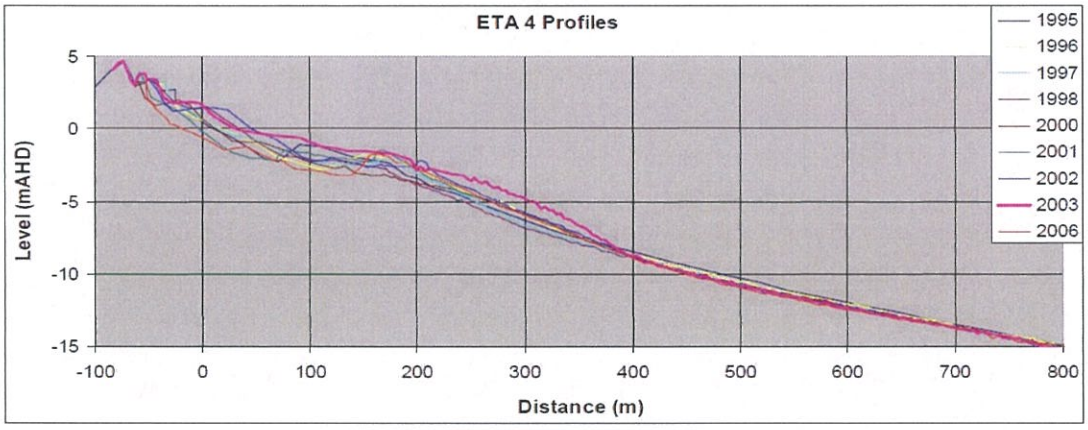

Figure 3-7 ETA 4 profile (Fingal) showing a sand 'bulge' in 2003 (Source: BMT WBM, 2011)

Away from the headland, Letitia Spit Beach usually exhibits a single or double bar system, and most of the sand transport is the result of littoral processes. Due to its wave exposure, gross longshore rates at Letitia Spit are amongst the highest along the STIS Project Area, and this beach experiences significant downcoast transport from time to time. Periods of significant downcoast (southwards) transport tend to occur mostly during spring and summer when the average wave direction is more northerly.

The vast majority of the longshore transport occurs in water depths of less than 4m; Hyder et al. (1997) estimates that approximately 73% of the gross transport sand occurs in water depths of less than 4m and approximately 91% in depths of less than 8m. At greater water depths, the East Australian Current becomes increasingly more significant, and is the dominant factor in water depths of more than 12m. Consequently, there is a net southward sand transport in water depths of more than 12m.

The sand bypassing jetty has an overall length of 450m, of which approximately 220m extend beyond the Tweed River training walls. The system has been designed to intercept the majority of the sand that is transported northwards under natural littoral processes and transport to the north of the Tweed River entrance. The ability of the bypassing jetty to intercept sand depends on the prevailing wave conditions, the shape of the slurry pit and the regional shoreline configuration. In recent years (2009-2015), the sand bypassing jetty has artificially bypassed an average 432,000m^3 of sand per year to the north of the Tweed River entrance. It thereby intercepted an estimated 70% of the net longshore transport along Letitia Spit and allowed an estimated 187,000 m^3 per year to 'leak' into the Tweed River entrance area (BMT WBM, 2017).

The exact pathways and mechanisms that cause sand leakage past the jetty are not completely understood, but it is likely that a large portion of the leakage occurs during major storm events when the littoral zone extends seaward of the jetty and the slurry pit is unlikely to trap all transport through the jetty.

The extension of the Tweed River training walls and the TRESBP bypassing operations have had a significant impact on the shoreline alignment of Letitia Spit. During the period 1962 and 1995, (the period between construction of the training walls and commencement of TRESBP Stage 1 operations), Letitia Spit experienced substantial accretion due to the construction of the training walls and the shoreline at the northern end of the beach moved seaward by some 200m. Since the start of TRESBP Stage 1 operations, and particularly during the supplementary bypassing period (2001 and 2008), the beach has experienced substantial erosion. By 2015, the sand volume within the northern part of the beach appears to have reached a state of dynamic equilibrium, but the central and southern parts appear to continue to experience a trend of erosion. Changes in the alignment of the upper beach have a direct impact on the net sand transport rate along the beach, with a counter clockwise movement resulting in increased northerly transport.

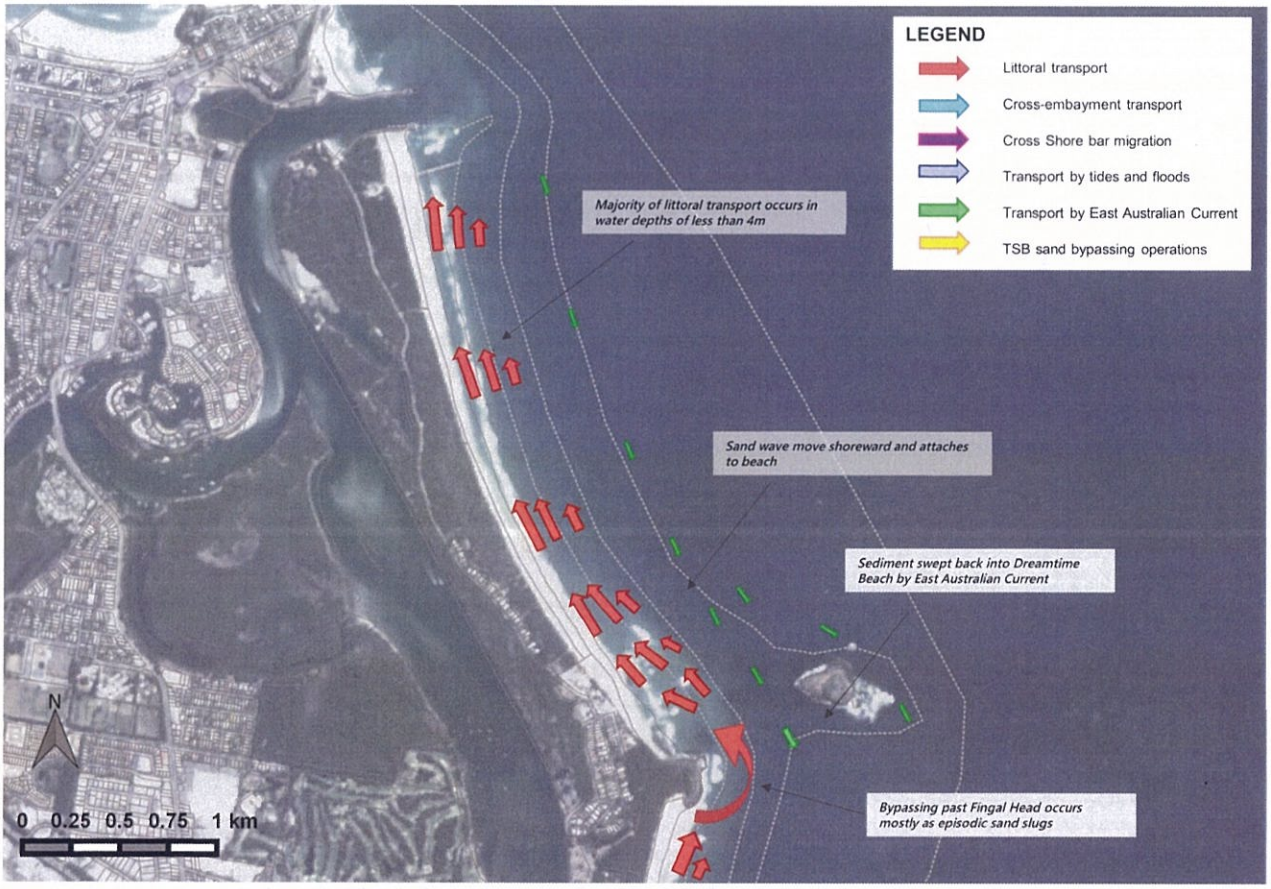

Figure 3-8 Conceptual model of sediment transport patterns through Letitia Spit & Fingal Head compartment

3.3 Tweed River Entrance

The main mechanism for natural sand transport across the entrance is bypassing via the entrance bar. It is however likely that some sand will also bypass the entrance via tidal currents in and out the river mouth. The processes influencing the movement of sand through the entrance are extremely complex. Sand transport across the entrance depends upon many interrelated factors, the most significant being:

- Longshore transport to the entrance area
- The configuration of the shoreline at the updrift side of the entrance
- The rate of sand extraction at the TSB jetty
- The configuration of the entrance, particularly the depth and shape of the entrance bar; and
- The effects of catchment runoff and tidal flows in and out the Tweed River mouth.

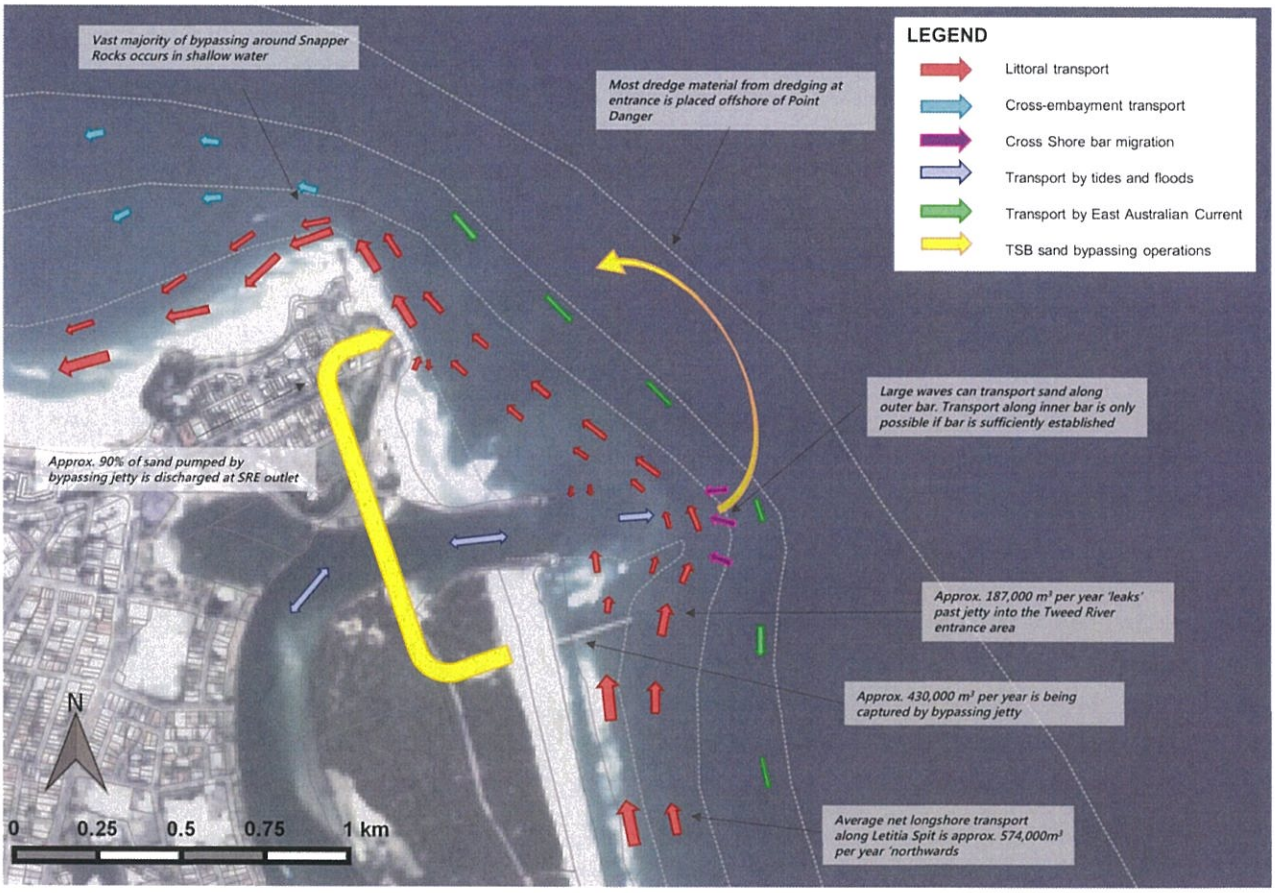

Figure 3-9 Conceptual model of sediment transport patterns at and around the Tweed River entrance

Figure 3-9 illustrates the principle of bypassing across the Tweed River entrance. Waves transport sand from the updrift shoreline towards the entrance. Some of the sand is transported from the updrift littoral zone directly to the entrance bar under the influence of waves and the persistent rip current that tends to be present at end of the downdrift beach. This sand is temporarily stored in the shoal or transported across the entrance by larger waves. Offshore of the inner bar, another sand transport pathway exists along the outer slope of the ebb delta. Transport via this pathway will almost entirely occur during east/southeasterly storms when larger waves are able to generate transport at greater depths. Once outside the principal influence of the ebb flow, waves

transport the sand both landward and further downdrift, where the pathway eventually rejoins the littoral zone of the Duranbah Beach / Point Danger. The result of this is a horseshoe shaped bar system.

The dimensions of the entrance bar that will form under natural processes are predominantly determined by the quantum of sand that is being supplied to the entrance and the local wave conditions. By increasing amounts of littoral drift, the depth of the bar will decrease and its width increase. Under the recent configuration whereby most of the littoral drift is bypassing the entrance through pumping at the jetty and an estimated net volume of 187,000 m^3/year 'leaks past the jetty (BMT WBM, 2017), without dredging of the entrance, the bar tends to develop to a height of about -3 to -4mAHD and is located 300 to 400m offshore of the river mouth.

Selected hydrographic surveys of the entrance from the period 2008 – 2016, shown in Figure 3-10, illustrate the typical development of the entrance bar from a dredged configuration and without any dredging in the entrance (In 2008 the entrance area was generally dredged to about -6.5mAHD and no significant dredging was undertaken until April 2016).

This figure demonstrates that the bar almost entirely develops as a prograding (advancing) spit from the south. That is, the infilling of the entrance channel is primarily driven by migration of a sand spit across the entrance. The average rate of growth of the spit was about 60,000 m^3 per year during the period 2009-2015, suggesting that in recent years most of the sand that is supplied to the entrance (approximately 187,000 m^3 per year, BMT WBM, 2017) is transported past the entrance in deeper water, offshore of the inner bar.

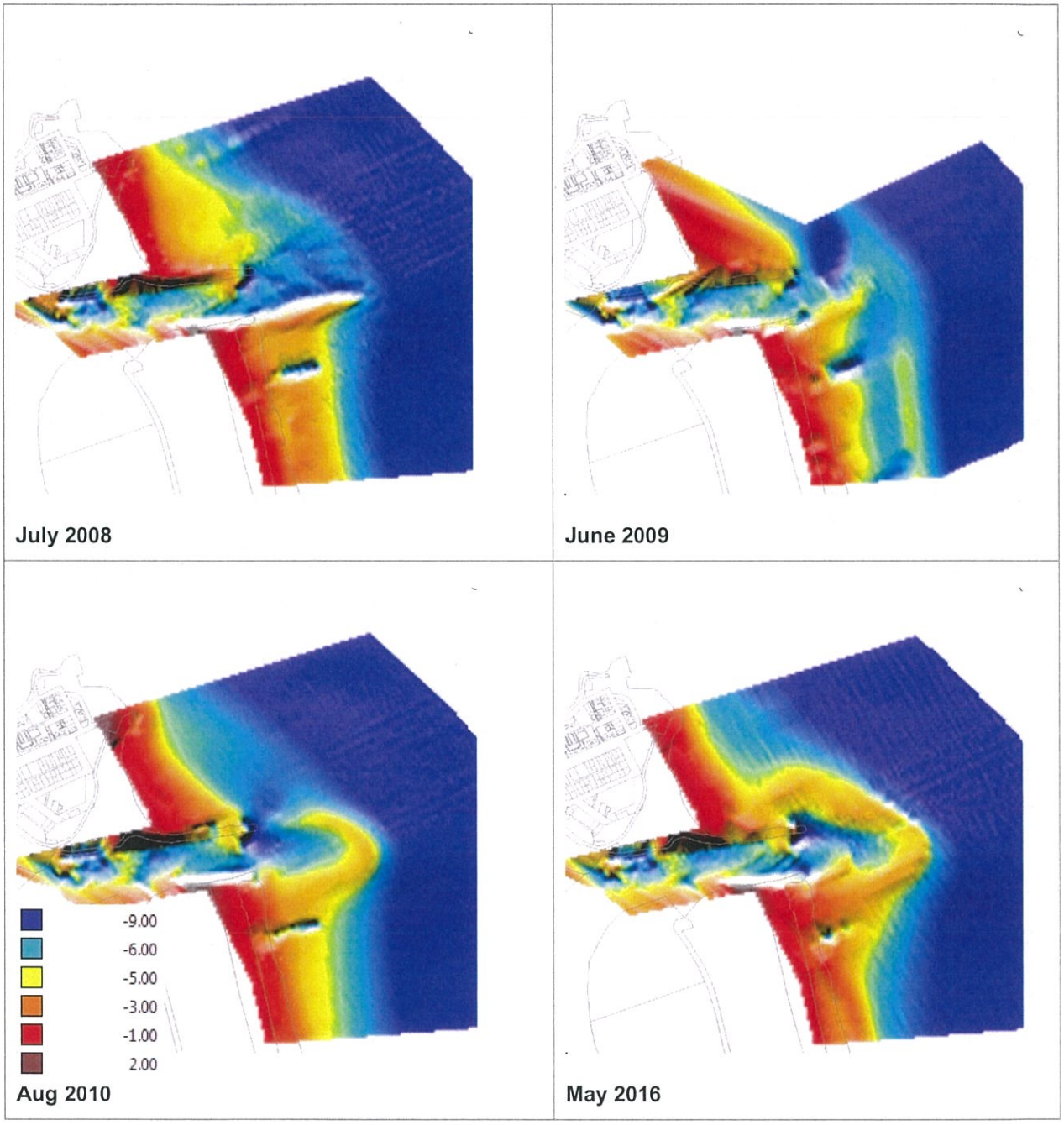

Figure 3-10 Hydrographic surveys of Tweed River entrance for period 2008 – 2016, illustrating typical entrance bar development

The Tweed River entrance bar is highly dynamic and sediment in the entrance area is constantly reworked. During severe storm events, volumes of sand in excess of 100,000m^3 can be moved from the bar into the entrance area under the influence of waves. Storm waves are capable of eroding the inner bar completely, and can lead to substantial sedimentation at the entrance. Following storm events, sand that has been deposited near the river mouth is generally moved out of this area reasonably quickly under the influence of tidal currents in and out of the estuary.

Tidal flows in and out the Tweed River mouth have thus a significant influence on the sediment transport regime of the entrance area. Generally, the tidal current patterns in the entrance area are characterised by a more or less radial inflow on the flooding tide and a concentrated ebb jet directed seaward on the ebbing tide. The nature and magnitude of the currents over the entrance bar depends on the bar configuration, and to a lesser degree on the shoal regime within the lower estuary. In particular, the peak flow currents during flood tides are sensitive to the bar configuration. When the entrance bar is fully developed, peak flow velocities during flood tides will be above 0.4m/s and will generate significant sand transport into the estuary. However, when the bar is dredged and the entrance is reasonably open, peak flow velocities over the bar may remain too weak to generate significant sand transport into the entrance.

During ebb tides, the current flows out of the entrance in a rather concentrated jet that generally remains quite defined for a distance of at least 400-600m offshore from the training walls. The ebb jet is generally flowing eastward centred around the river mouth, but may be deflected to the north or south under the influence of winds, waves, the East Australian Current or the local bar/channel bathymetry. Peak flow velocities typically reach up to about 1.5m/s over the entrance bar, and reduce in magnitude immediately seaward of the shoal. Occasionally, the ebb jet interacts with the northerly wave-driven currents along Letitia Spit and Eastern Australian Current in deeper water to generate a large-scale clockwise circulation cell on the southern side of the river. This circulation cell may strengthen the wave-driven current within the surfzone of Letitia Spit and could potentially facilitate a sand transport pathway towards the entrance area (Helyer et al., 2011).

Flood events in the Tweed River catchment can deliver substantial volumes of sand to the entrance area from the lower estuary. Hydrographic surveys of January 2017 and April 2017 suggest that more than 150,000m^3 of sand was delivered to the entrance area during the March 2017 flood event, a significant flood event with a return period of about a 1 in 20 years at Uki. Figure 3-11 shows that during this event the majority of the sand became deposited between the entrance and the bar by building a mild sloped wedge against the inner bar

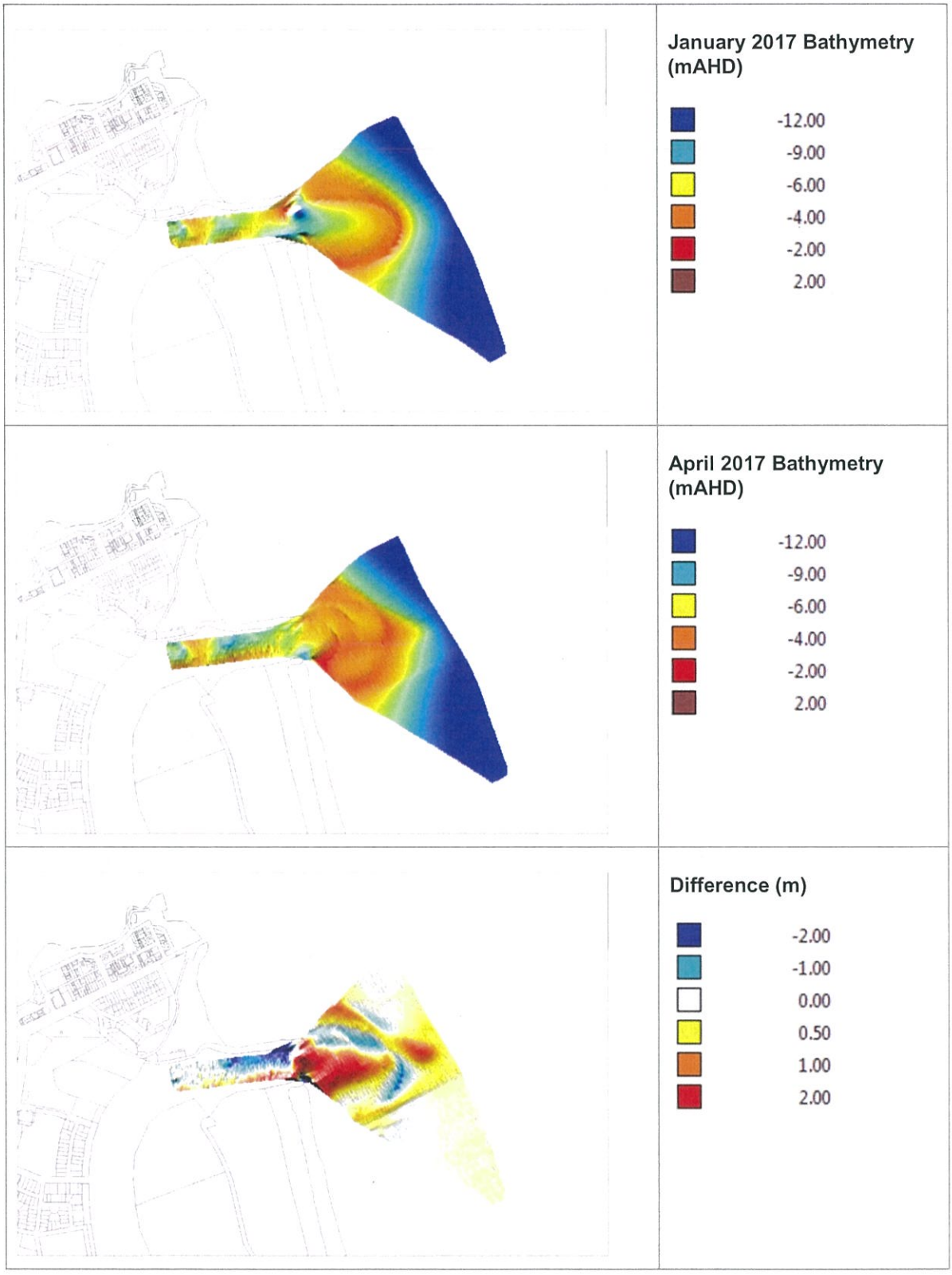

Figure 3-11 Pre- and Post-March 2017 flood event surveys, illustrating sedimentation patterns of a major flood

3.4 Tweed Estuary

Although the Tweed River is not part of the open coast, there is significant sand exchange between the lower estuary and the entrance area, and as such is of importance in the overall sediment transport regime of the STIS Project Area.

The Tweed River has a catchment of approximately 1100 km^2 that experiences a humid sub-tropical climate with a marked wet season that extends from December to April. Heavy rainfalls with falls of 250mm in 24 hours are not unprecedented in the catchment, and consequently the river experiences frequent flood flows. The river has an estuary area of approximately 22.7 km^2 (DECCW, 2010) and includes the main Tweed River channel system and the tidal broadwaters of Terranora and Cobaki, which connect to the main channel via Terranora Creek about 2km upstream of the river entrance. The main river is tidally influenced up to Murwillumbah, some 30km upstream of the river mouth. The tidal prism of the river is approximately 13.5 Mm^3 during large spring tides (OEH, 2015).

The morphology of the lower estuary is characterised by a fairly complex bathymetry of sand shoals and channels. The vast majority of the bed sediment within the lower estuary comprises marine sand and bed forms of the sediments indicate active sand transport under tidal processes. Extensive bedrock outcrops occur in the outer bend of the main channel near Jack Evans Boat Harbour, just inside of the training walls (Refer to Figure 1-1).

The lower Tweed River estuary has a strong tendency towards the establishment of a unique pattern of tidal shoals, and will generate significant net sediment fluxes in and out of the entrance in response to modifications in bed levels within the lower estuary or at the entrance. For example, Druery and Duredale (1979) indicates that the net sand influx into the lower estuary from the entrance exceeded 84,500 m^3 per year in the 1920s, as the lower estuary was adapting to the construction of the initial river training walls at the turn of the 20th century. Similarly, BMT WBM estimates that the average annual influx of sand from the entrance was about 126,000 m^3 during the period 1972 to 1983, due to the combined effects of extension of the river training walls in 1962 and major dredging works that were conducted in the lower estuary in the 1970s. Both in response to the initial training wall construction, as well as the extension in the 1960s, it took about 30 years for the shoal regime to adapt. It is estimated that the lower estuary held approximately 1.4 million m^3 more sand in 1993, compared to 1962. Since TRESBP bypassing commenced in 2001, there appears to be a trend of sand supply from the lower estuary to the entrance.

The capacity of the shoal regime to adapt to changes is associated with the configuration of the Tweed River entrance. When the entrance area is not heavily shoaled, sand transport through the training walls will reduce, and so does the ability for the lower estuary to adapt.

Major flood events in the Tweed River catchment tend to result in scouring of the estuary shoals and can result in significant volumes of sand being transported from the lower estuary to the entrance area. Following flood events, sand that has been deposited in the immediate entrance area tends to be moved away by tidal currents. As a result, some of the sand may be transported back into the estuary.

3.5 Point Danger to Snapper Rocks

The TSB sand bypassing operations have had a significant impact on the sand supply to this compartment from the Tweed River entrance. Due to the reduced natural bypassing around the Tweed River entrance, the lower beach profile of this compartment has seen significant erosion, particularly the zone between -5mAHD and -10mAHD.

At present, the vast majority of the sand through this compartment is supplied via the Snapper Rocks East outlet. This outlet, located at Point Danger, is the primary discharge location for sand pumped by the TSB bypassing jetty. Over the life of the project to date, approximately 90% of the total sand volume pumped (or 7.5M m^3) has been discharged at this location. The Snapper Rocks East outlet is a fixed pipeline release that discharges the sand as a slurry above mean sea level just off the cliff face of Point Danger.

The nearshore area around Point Danger is highly dispersive with sand placed by the pipeline usually quickly dispersing even under relatively mild metocean conditions. Discharge rates of more than 100,000m^3 per month have not been uncommon during the winter months of the initial years of sand pumping, but have rarely resulted in a lasting deposition of sand around the discharge location. Instead, the sand tends to be transported away by littoral transport processes.

Most of the sand transport along Point Danger occurs in a narrow zone in close proximity to the shoreline.

3.6 Coolangatta-Kirra Embayment

The bathymetric changes experienced over the last 50 years, outcomes of the sand tracing study (HaskoningDHV, 2017) and the nature of the wind and wave driven currents suggest that the sand transport regime through the Coolangatta-Kirra embayment occurs as both:

- Littoral zone alongshore transport, priarily driven by breaking waves and wave-driven currents; and
- Cross-embayment mass transport outside the littoral zone where the transport is mostly driven by wave asymmetry (in the direction of wave travel), wind and broader wave radiation stress gradients

Thus, conceptually, the sand transport through this compartment may be considered as following two distinct pathways, defined by somewhat different mechanisms that drive it.

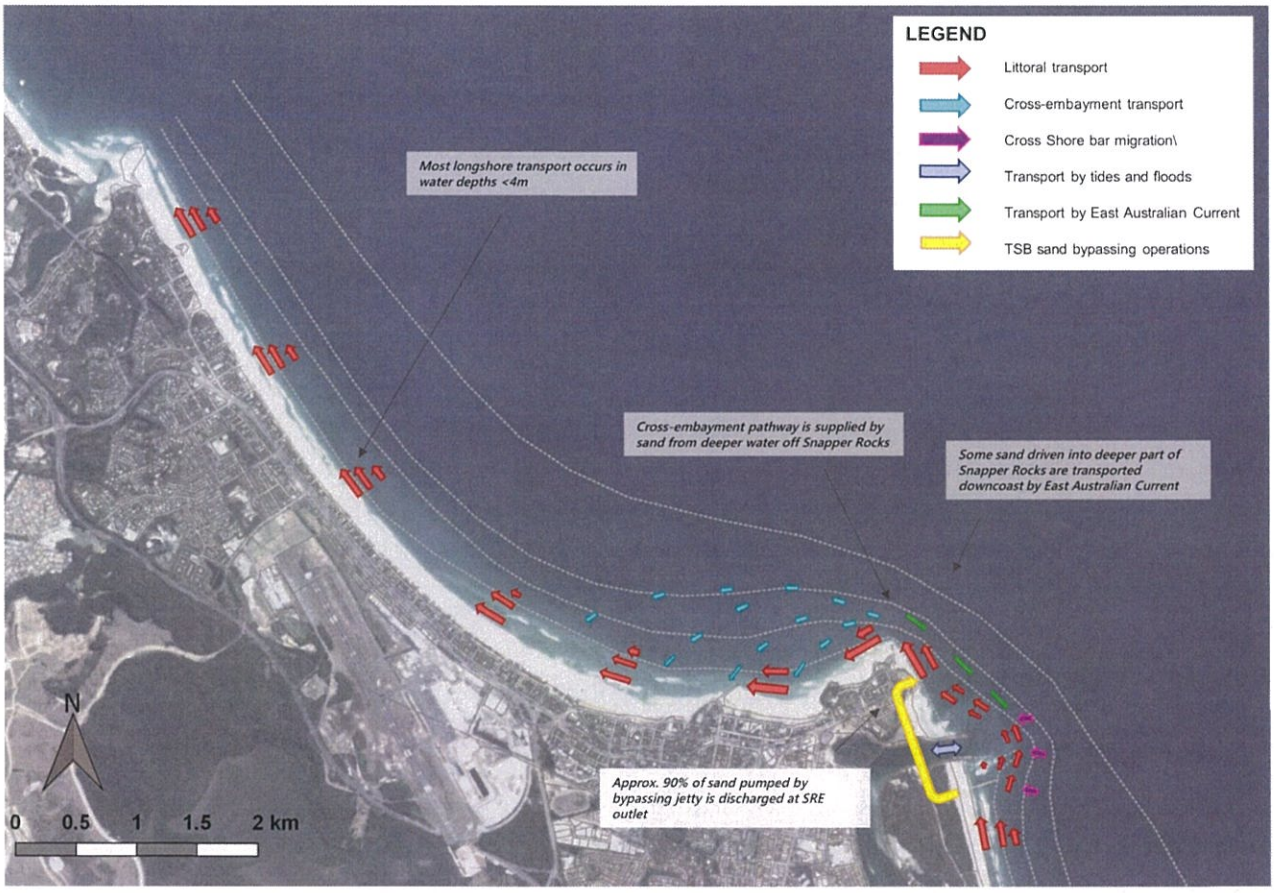

Figure 3-12 Conceptual model of sediment transport patterns through Coolangatta-Kirra embayment and Tugun-Currumbin

The littoral transport is confined to depths not much greater than the wave breakpoint depths, probably up to about 6-8m within the embayment, as demonstrated by the historic bi-modal beach profile response at Coolangatta (Refer to Figure 3-13).

The extent of cross-embayment sand transport is less clearly defined and most probably decreases progressively with depth as the influence of the waves on the bed, wave asymmetry and the strength of induced net currents decreases. A recent sand tracing study (HaskoningDHV, 2017), whereby tracing material released at a location near Point Danger was sampled on a number of occasions following its release in May 2016, found tracing material at a location approximately 800m north of Kirra Point, in about 12m of water depth (See Figure 3-14). Macdonald and Patterson (1984) suggest that the cross embayment may extend to about 15m, based on analysis of beach profile evolution at Kirra and Coolangatta following construction of the Tweed River training walls.

The proportion of sand that follows the littoral zone and the proportion that moves across the embayment as cross-embayment transport have not been quantified reliably. These will almost certainly vary with varying wave and sand transport conditions, with a higher littoral proportion of littoral transport, but lower total transport, under lower wave energy conditions.

It is likely that the sand bypassing operations have influenced the proportion of sand that follows the littoral zone and the proportion that moves across the embayment as cross embayment transport. Since commencement of TSB sand pumping in 2001, the sand transport regime around Snapper Rocks appears to have changed somewhat with more sand transport past the headland taking place in shallow water depths and less being transported through the cross-embayment sand transport pathway. This is evident from the progressive gains of the upper beach volume of Rainbow Bay and Snapper Rocks, and the progressive loss of volume in the lower beach profiles of Rainbow Bay, Snapper Rocks and Coolangatta, particularly the zone between -5m and -10mAHD. This trend of progressive sand loss from the lower beach profile appears to be ongoing, with no sign of moderating at most locations.

The proportion of sand that follows the littoral zone and the proportion that moves across the embayment will vary along the embayment shoreline, with an increasing amount of the cross-embayment component re-joining the littoral zone further north along the shoreline. The morphologic evidence indicates that the longshore sand transport becomes exclusively 'littoral' at or just south of the northern end of Bilinga Beach. The cross-embayment pathway is expected to almost entirely bypass Snapper Rocks, Rainbow Bay and Greenmount.

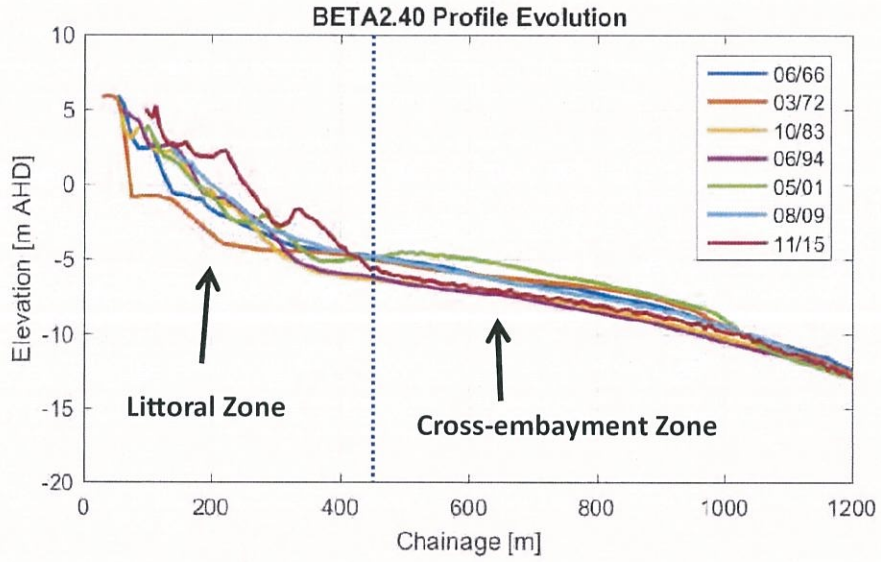

Figure 3-13 Coolangatta Beach profiles providing evidence of cross-embayment sand transport

Figure 3-14 Tracer material concentrations 9 months after release (HaskoningDHV, 2017)

Rainbow Bay and Little Marley's are relatively small, north facing beaches. These beaches generally receive waves that are substantially lowered due to the influence of the headland. The width of both beaches and offshore bank conditions depend on both the prevailing wave climate and sand supply around the headland.

During the winter months, the wave climate is mostly influenced by swell, and consequently the wave direction is more southerly. Due to the more southerly waves, above average rates are being discharged by the bypassing jetty at the Snapper Rocks East Outlet, and transported northward around Snapper Rocks. Past Snapper Rocks, the transport capacity of the more southerly waves reduces, and sand temporarily accumulates in the lee of the headland. As a result, the beach width of Rainbow Bay and Little Marley's increases and the beaches often become connected by sand.

During spring, the average wave direction moves anti-clockwise, and northeasterly waves become more prevalent, accompanied by more frequent northerly winds. This means that the sand pumping rates through the bypassing jetty tend to significantly reduce and less sand is transported around Snapper Rocks. At the same time, the longshore transport capacity at Rainbow Bay and Little Marley's increases during spring and summer, which leads sand being moved away from these beaches and a general reduction in the overall beach width during these periods.

Severe northeasterly storm events are particularly unfavourable for maintenance of the sand bank immediately offshore of Snapper Rocks, as during these storms waves cause sand transport away from the headland on both sides (ie. downcoast along Frog's Beach/Point Danger and upcoast along Little Marleys/Rainbow Bay, which can result in large volumes of sand being removed from the Snapper Rocks area. Often a scour hole of several metres deep develops just offshore of the bed rock of Snapper Rocks and the bank can almost entirely disappear, with most of the sand migrating westward towards Rainbow Bay/Greenmount. Surf conditions following such an event are generally poor. It can take some years for the offshore bank to fully recover, as the recovery process relies heavily on large southeasterly waves to transport sand from the lower beach profile of Frog's Beach area into the eroded areas off Snapper Rocks.

The impact of large northeasterly wave events is illustrated in Figure 3-15 and Figure 3-16, which present the bathymetry around Snapper Rock before and after a series of storms that occurred during the autumn of 2009 and caused severe erosion along most of the Northern NSW / Gold Coast region. The most severe of these storms occurred from 19 to 25 May 2009 during which a maximum significant wave height of 5.6m was recorded at the Tweed Head wave buoy and the significant wave height remained above 4m for a period of approximately 4 days.

Figure 3-15 and Figure 3-16 show that a substantial scour hole of several metres deep developed offshore of Snapper Rocks. During the storm events, approximately 70,000m^3 of sand was eroded from the offshore sand bank.

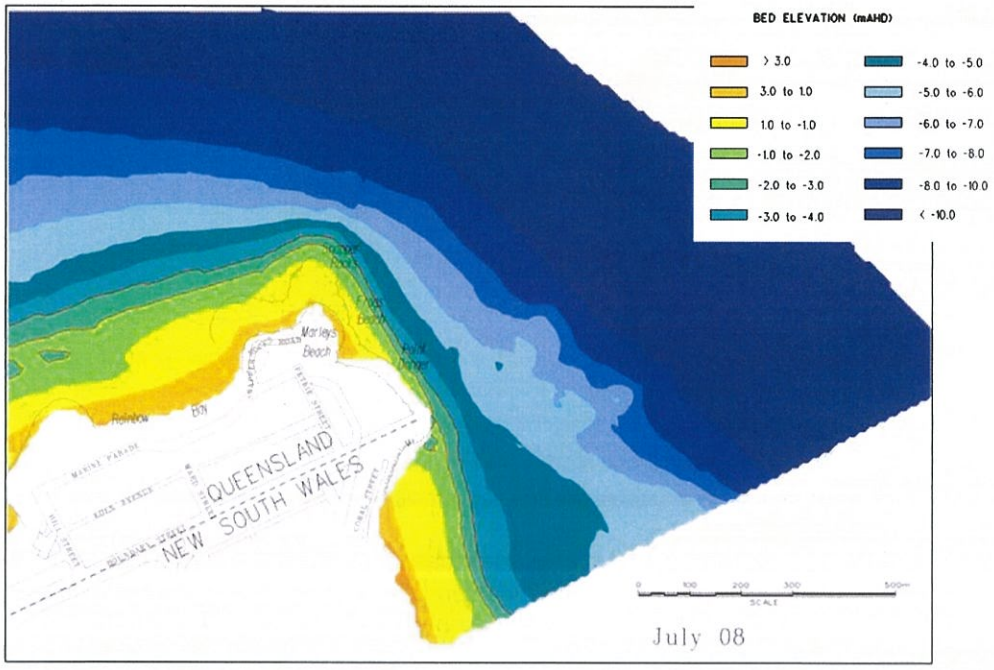

Figure 3-15 Pre- Autumn 2009 Storms Bathymetry around Snapper Rocks

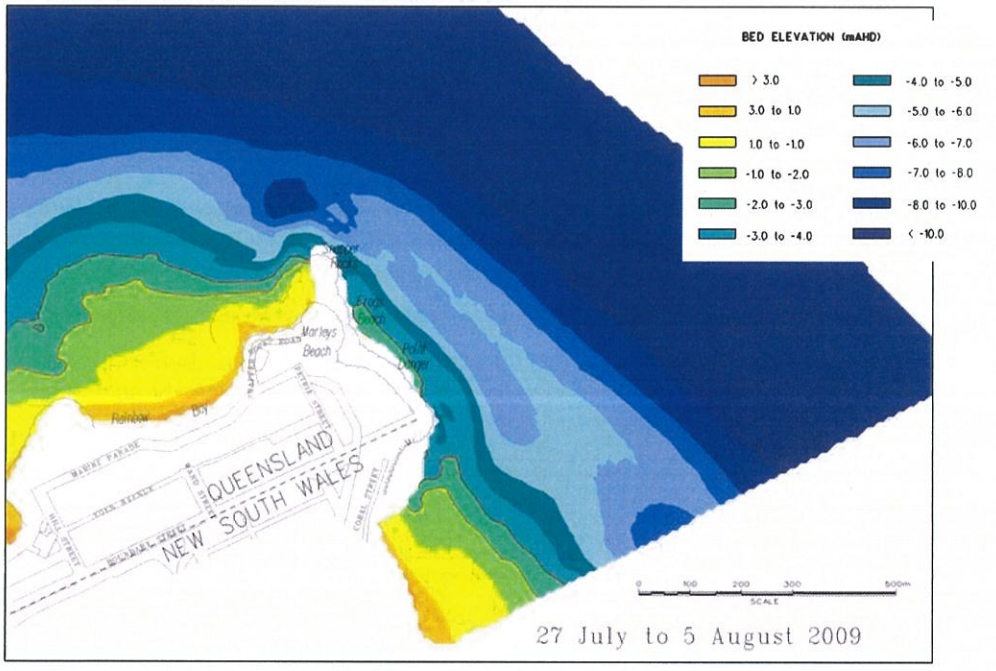

Figure 3-16 Post- Autumn 2009 Storms Bathymetry around Snapper Rocks

3.7 Tugun & Currumbin

This compartment extends from the northern end of Bilinga to Currumbin Rock in the north and encompasses Tugun and Currumbin Beach. Tugun and Currumbin form part of a somewhat larger embayment that extends from Kirra Point to Currumbin Point, and is slightly curved. The beach is separated by Elephant Rock, Flat Rock and Flat Rock Creek, a small coastal creek that drains across the beach between Elephant Rock and Flat Rock.

Currumbin Beach is fully exposed to north through easterly ocean waves, but receives protection from Snapper Rock during south-easterly and south swell conditions and, as such, the littoral sand transport processes along the entire beach remain influenced by the effects of Snapper Rocks. Even though the influence of the headland progressively reduces moving north along the shoreline, it remains significant at Currumbin Rock.

The construction of the Currumbin Rock groyne has had a significant impact on the shoreline between Currumbin Rock and Elephant Rock. Since its construction in 1973, the beach has become more stable and the upper beach has experienced significant accretion. The beach profile between Currumbin Rock and Elephant typically gained in the order of 1,000m^3/m.

Currumbin Beach usually exhibits a single or double bar system, with prevalent rip channels across the inner bars. The sand transport through this compartment occurs exclusively as littoral transport with the vast majority of the longshore transport occurring in water depths less than 4 metres, as shown in Figure 3-12.

Figure 3-17 Aerial photo of Currumbin Beach in 1970 showing rock revetment adjacent to Marine Parade

4. Knowledge Development Planning

Although considerable knowledge is available from previous scientific and engineering studies and data analyses, it is recognised that a full understanding of the processes influencing the transport of sand through the STIS does not exist. The natural physical processes of sand movement in the Project Area are variable and highly complex, and have a substantial influence on the sand bypassing operations of the TSB. In turn, the bypassing operations of the TSB affect the natural processes.

A knowledge gap analysis was undertaken to identify the critical knowledge gaps that exists in the current understanding of the sediment transport processes operating within the STIS, including the effects of TSB's sand bypassing operations; and recommend methodologies to fill these knowledge gaps. The outcomes of this knowledge gap analysis are summarised in Table 4-1.

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Table 4-1 Knowledge Gap Analysis

Aspect	Knowledge Issue	Knowledge held	Knowledge Gap	Methodology to Gain Knowledge
Fingal to Currumbin sand transport differential	Recent investigations have suggested that the net transport of sand into the system at Fingal is larger than the net transport out of the system at Currumbin. The cause and validity of this apparent ongoing differential is currently unknown.	Information held by TSB to enable further investigation of this aspect includes: • Wave and longshore transport models • Historical beach profile and hydrographic surveys • Shoreline evolution model • Historical recorded wave and metocean datasets	There is uncertainty as to the cause of the differential and whether it is a result of error in the calculation of sediment transport budgets and whether it is in fact reflecting reality. Potential explanations include: • Longshore transport at Currumbin has been impacted by anthropogenic activities, both direct and indirect • Transport rates are affected by inter-decadal variability in the wave climate, which may have affected the longshore transport regime • Transport differential is due to processes that operate on geological timescale processes related to the Holocene transgression	• Determine the locations of sand volume changes and assess degree of change that can be attributed to anthropogenic actions such as groyne construction of and dredging • Investigate the sensitivity of the longshore transport at Currumbin to changes in (deepwater) bathymetry • Conduct longshore transport modelling at additional locations to validate modelled rates and provide regional context • Conduct geomorphological study to provide understanding of the ongoing effects of Holocene transgression.

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Aspect	Knowledge Issue	Knowledge held	Knowledge Gap	Methodology to Gain Knowledge
Tweed Entrance Dynamics	Although the concept of the Tweed Entrance dynamics is well understood. A detailed understanding of the sensitivity of the entrance bar formation is currently not documented. The Tweed entrance dynamics is an important process which has an impact of critical operational issues such as impacts safe navigation and the TSB dredging programme	Information held by TSB to enable further investigation of this aspect includes: • Historical beach profile and hydrographic surveys • Historical recorded wave and metocean datasets • Recorded current datasets in the Tweed River entrance	The sensitivity of the entrance bar formation to flood and metocean events and different dredging campaigns is not fully understood. A better understanding of the bar dynamics could assist in improved management of the entrance dredging campaign.	• Sediment transport modelling of the entrance area to simulate transport under a range of entrance configurations and metocean and flood conditions • Conduct flow current measurements to provide insight in hydrodynamics around the jetty under a range of metocean conditions
Sand leakage through jetty	The exact pathways and mechanisms that cause sand leakage are not fully understood. 'Leakage' can result in significant contributions to channel deposition and entrance bar formation which can in turn impact navigability and dredge campaign volumes.	Information held by TSB to enable further investigation of this aspect includes: • Wave and longshore transport models • Historical beach profile and hydrographic surveys • Sand transport model • Historical recorded wave and metocean datasets	Pathway and mechanism of 'leakage' are not fully understood. Better understanding of the mechanism for sediment to bypass through and around the jetty and slurry pit could result in better planning of future operations and potential infrastructure modifications.	• Data analyse of existing information, assisted with numerical sediment transport modelling, to provide quantitative understanding of circumstances that lead to 'sand moving past the jetty. Sediment transport model should be able to accurately represent the effects of slurry pit. • Liaise with contractor to learn from his experiences (observations of historical leakage, operational challenges, opportunities to optimise the pumping system or operations)

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Aspect	Knowledge Issue	Knowledge held	Knowledge Gap	Methodology to Gain Knowledge
Sand placement operations	The lower beach profile throughout the Coolangatta-Kirra embayment appears to be subject to ongoing erosion. The effects on long-term shoreline processes are poorly understood.	Information held by TSB to enable further investigation of this aspect includes: • Wave and longshore transport models • Historical beach profile and hydrographic surveys • Shoreline evolution model • Historical recorded wave and metocean datasets	The source of ongoing erosion of the lower beach profile of the Colangatta-Kirra embayment is unknown. Further analysis would be required to identify the source of this trend, assess the nature of the impacts, and whether mitigations are required.	• Detailed analyse of previous placement operations and sand tracing study results to infer sediment pathways and rates towards Snapper Rocks. • Sand tracing study with release at deepwater location off Snapper Rocks • 2D sediment transport modelling of transport around Snapper Rocks
Transport of sand	During the "supplementary increment" period (2001-2008), the total supply to the southern Gold Coast beaches was higher than the estimated natural longterm average sand transport. This period of oversupply continues to affect the Project Area, with most of the change in recent years occurring as sand lobes between -5 and -10mAHD along Bilinga North and Tugun.	Information held by TSB to enable further investigation of this aspect includes: • Wave and longshore transport models • Historical beach profile and hydrographic surveys • Historical recorded wave and metocean datasets • Shoreline evolution model	There is uncertainty how sand will migrate from these sand lobes northwards, making prediction of adaptation timeframes difficult.	• Detailed monitoring of sand movement around sand lobes (surveys, tracing study) • 2D sediment transport modelling study of Bilinga North, Tugun and Currumbin

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Appendix G
Stakeholder Consultation

NSW GOVERNMENT | Department of Industry

Reference: DOC18/xxxx

Address 1
Address 2
Address 3

Dear xxxx

Updated Review of Environmental Factors for the Proposed Back Passing by Dredge – Tweed River Entrance Sand Bypassing Project

Please find attached an updated Review of Environmental Factors (REF) for the back passing of sand from the Tweed River entrance. It is proposed to dredge sand, store it on the dredge barge and transport it south for placement in two nearshore deposition areas to facilitate beach nourishment.

The proposal is for a nominal annual placement of 50,000m^3 across two deposition areas, one adjacent to Letitia Beach (north of Fingal Head) and the second adjacent to Dreamtime Beach (south of Fingal Head) on the Tweed coast (Figure 1 below).

Of the annual total placement of 50,000m^3, an annual total restriction of 20,000m^3 will apply to Dreamtime Beach. The deposition areas have a combined total area of approximately 750,000m^2 and are located parallel to the beach, between 3m – 13m depth contours.

The proposal presents a new and complementary combination of dredging and sand nourishment to meet the objectives of the Tweed River Entrance Sand Bypassing project (TRESBP) which are to maintain a safe navigable entrance to the Tweed River and to restore and maintain the amenity of the beaches on the southern Gold Coast of Queensland.

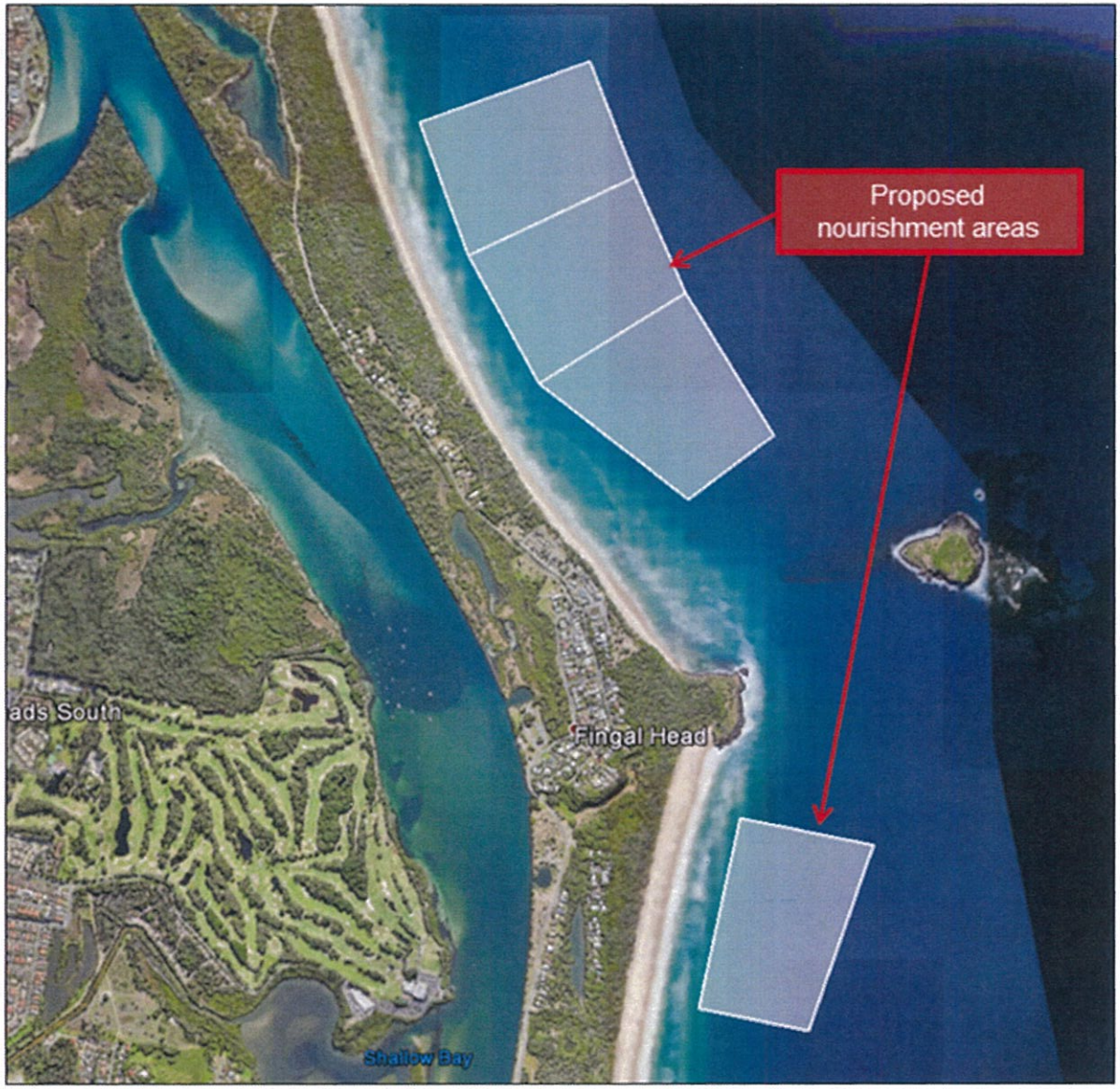
In accordance with State Environmental Planning Policy (Infrastructure), Crown Lands is required to give notice to relevant state and local government authorities on their intention to carry out proposed activities. Response to that notice is required within 21 days. All responses will then be taken into consideration in finalising the REF.

To meet this requirement, please review the attached REF and forward your written response to Matthew Harry by Friday 22 February, 2019 by e-mail to matthew.harry@crownland.nsw.gov.au

Yours sincerely

Kim Bowra
A/Project Manager for the NSW and Qld Governments – Tweed Sand Bypassing
Department of Industry – Crown Lands
For the Principal

Xxxx January 2019



NSW GOVERNMENT | Department of Industry

Figure 1: Proposed sand nourishment areas

The proposal involves the dredging, transport and deposition of sand sourced from the Tweed River entrance by a dredge barge vessel so as to maintain a navigable channel.

The sand will be dredged by and stored on the vessel, transported south and placed in the nourishment areas.

The nourishment areas are located off Letitia Beach north of Fingal Head and Dreamtime Beach south of Fingal Head. The nourishment deposition areas are located parallel to the beach, between 3m – 13m depth contours.

The proposal is for a nominal annual placement of 50,000m^3 across both nourishment areas. This is inclusive of a 20,000m^3 annual total restriction at Dreamtime Beach.

Stakeholder Consultation List – Backpassing REF

Agency	Name	Title	Address	Email	Phone
DPI-Fisheries	Jonathan Yantsch	Fisheries Manager, Aquatic Ecosystems (North Coast)	NSW Department of Primary Industries 1243 Bruxner Hwy Wollongbar NSW 2477	jonathan.yantsch@dpi.nsw.gov.au	(02) 6626 1375 0447 537 168
OEH	Dimitri Young	Senior Team Leader Planning, North East Branch	NSW Office of Environment & Heritage Locked Bag 914 Coffs Harbour NSW 2450	rog.ne@environment.nsw.gov.au (cc Ben.Fitzgibbon@environment.nsw.gov.au)	(02) 8289 6318
EPA	Scott Ensbey	Operations Officer – North Coast	NSW Environment Protection Authority PO Box A290 Sydney South NSW 1232	scott.ensbey@epa.nsw.gov.au	(02) 6640 2522 0447142916
RMS	Lynda Hourigan	Project Officer North	Roads & Maritime Services PO Box 426 BALLINA NSW 2478	navigationadvicenorth@rms.nsw.gov.au	0409 483 676
Crown Lands	Derek van Leest	Group Leader Property Management Far North Coast	NSW Department of Industry - Lands PO Box 2185 Dangar NSW 2309	derek.van.leest@crownland.nsw.gov.au	(02) 6642 9236 0429 072 877
Planning		NSW Department of Planning Locked Bag 9022 Grafton NSW 2460	NSW Department of Planning Locked Bag 9022 Grafton NSW 2460	northcoast@planning.nsw.gov.au	
Tweed Shire Council	Jane Lofthouse	Unit Coordinator Natural Resources Management	Tweed Shire Council PO Box 816 Murwillumbah NSW 2484	jlofthouse@tweed.nsw.gov.au	(02) 6670 2743 0419 493 937
Tweed Byron Local Aboriginal Land Council	Gina Combo	Cultural Heritage Operations Coordinator	PO Box 6967 Tweed Heads South NSW 2486	admin@tblalc.com	(07) 55 361763 0484 001345
DoEE					

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OUR REF: C18/295

19 June 2018

Mr matthew Harry
Environmental Officer
Department of Industry - Lands
PO Box 624
BALLINA NSW 2478
Via email: matthew.harry@crownland.nsw.gov.au

Dear Mr Harry

Re: Environmental Study Requirements for amendments and additions to the Tweed Sand Bypassing Project

I refer to your email of 29 May 2018 seeking comments on the development of the Review of Environmental Factors (REF) for a proposed amendment to the planning and environmental approvals, and lodgement of a development application for a new dredged sand placement area for the Tweed Sand Bypassing Project. The above mentioned proposal is likely to have direct impact on key fish habitats and has the potential to impact upon the Cook Island Aquatic Reserve. Cognisant of this, I have outlined below the environmental study requirements necessary to facilitate appropriate assessment of the above mentioned proposal.

DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is "no net loss" of key fish habitats upon which they depend. To achieve this, the Aquatic Ecosystems Unit assesses activities under Part 4 and Part 5 of the *Environmental Planning and Assessment Act 1979* in accordance with the objectives of the *Fisheries Management Act 1994* (FM Act), the aquatic habitat protection and threatened species conservation provisions in Parts 7 and 7A of the FM Act, and the associated and *Policy and Guidelines for Fish Habitat Conservation and Management (2013 Update)* (Dpi Fisheries P&G). This document is available online at: https://www.dpi.nsw.gov.au/fishing/habitat/protecting-habitats/toolkit. In this instance, because the works are immediately adjacent to the Cook Island Aquatic Reserve, the matter has also been considered against the objects of the *Marine Estate Management Act 2014* and the Marine Estate Management (Management Rules) Regulation 1999.

Part 7 *Fisheries Management Act 1994* Approvals

The table below outlines actions that trigger sections of the FM Act. The proposal will involve dredge and reclamation works and details of the proposal will be required to be provided in accordance with the consultation provision under s199 of the FM Act.

Sections	Description of action	Legislative trigger
198-202	Dredge (digging) and / or reclamation (filling) of land permanently or periodically inundated by water (including wetlands).	Digging and / or filling below the Highest Astronomical Tide (~1m AHD) in estuaries. Digging and / or filling within the high bed of 3rd order watercourses (based on 1:25,000 scale maps). Draining water from land for its reclamation. Activities described in cl 263 *Fisheries Management (General) Regulation* 2010
205	Harming marine vegetation (seagrass, mangroves and kelp)	Gather, cut, pull up, destroy, poison, dig up, remove, injure or otherwise harm marine vegetation or any part of it. Activities described in cls 260-262 *Fisheries Management (General) Regulation* 2010
218-220	Obstructing free passage of fish, in waterways	Construction or alteration of a dam, floodgate, causeways or weir or otherwise creation of an obstruction

Cook Island Aquatic Reserve

Cook Island Aquatic Reserve (the Reserve) is in the vicinity of the proposed spoil disposal sites. The Reserve is protected due to its unique combination of temperate, subtropical and tropical species of fish and invertebrates including corals, in a complex of rocky reefs. Corals are particularly vulnerable to sedimentation due to reduced light penetration and/or smothering. This area is to be protected as a priority and there should be no harm to animals or plants as a result of this work. No sand spoil should migrate into the Reserve.

A potential impact of the proposal on the Reserve is that sand originating from the spoil disposal sites enters the Reserve via long-shore drift. The draft REF highlights that the long-shore drift of sand at the Tweed is generally in a northerly direction, although it does not provide any information on the risk posed to the Reserve by sand migrating out of the disposal sites. The Dreamtime Beach spoil location site is of particular concern as it is situated immediately to the south of the Reserve therefore placing it immediately within the path of sand originating from the spoil disposal site and migrating northwards via long-shore drift. The REF should provide further information on the likely sand migration pathways and volumes of sand originating from the spoil disposal sites in relation to the Reserve to quantify that sand originating from the spoil disposal site will not impact the Reserve.

It should also be noted that the completed REF will be required to be referred to DPI Fisheries in accordance with the *Marine Estate Management Act 2014*.

Division of Primary Industries, DPI Fisheries
1243 Bruxner Highway, WOLLONGBAR NSW 2477
Ph: 0447 537 168 ABN: 72 189 919 072 www.dpi.nsw.gov.au

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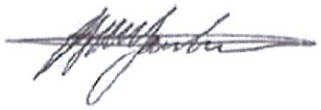
Other information requirements

DPI Fisheries' standard minimum information requirements for environmental assessment are clearly detailed in section 3.3 of the policy and guidelines. Please ensure that the proponent addresses these requirements in their environmental studies. This will facilitate effective assessment of the proposal and reduce delays.

If you have any further enquiries please contact me on 0447 537 168 or jonathan.yantsch@dpi.nsw.gov.au.

Yours sincerely



Jonathan Yantsch
Fisheries Manager, Aquatic Ecosystems (North Coast)
Aquatic Environment, Primary Industries NSW

CC: Lesley Diver, **Senior Project Officer, Marine Parks and Aquatic Reserve**

Division of Primary Industries, DPI Fisheries
1243 Bruxner Highway, WOLLONGBAR NSW 2477
Ph: 0447 537 168 ABN: 72 189 919 072 www.dpi.nsw.gov.au

Transport
Roads & Maritime
Services

Reference: DOC18/110775

12 June 2018

Mr Matthew Harry
Environmental Officer – Tweed Sand Bypass
NSW Department of Industry - Lands
PO Box 624
BALLINA NSW 2478

Email: matthew.harry@crownland.nsw.gov.au

Dear Mr Harry

Proposed Backpassing by Dredge – Tweed Sand Bypassing Project

Thank you for your letter of 29 May 2018 about the proposed development application for a new dredged sand placement area on Letitia Spit in NSW.

Roads and Maritime Services (RMS) supports the proposed maintenance dredging activity for a new dredged sand replacement area on Letitia Spit in NSW for navigational facilities to improve operational flexibility and entrance management of the Tweed Sand Bypassing project. RMS advises the standard conditions outlined below are applicable.

Standard Conditions

- Any Dredge and all associated work boats to comply with the relevant Marine Legislation for survey, registration and safety equipment
- Vessels must exhibit lights and shapes in accordance with International Regulations for Preventing Collisions at Sea
- All pipes and ancillary equipment which presents as a potential hazard to people or vessels should be appropriately marked, including the use of lights at night. Marking of objects to be clarified with RMS Boating Safety Officer prior to placement.
- Submerged pipelines may present as a hazard to anchoring, in some locations. This hazard must be mitigated, and appropriate signage may be an option.
- A suitable Vessel Traffic Management Plan to minimise disruption to other vessels may need to be implemented. This may include placement of additional navigation aids to warn the boating public of potential hazards.
- Whilst dredging operations are underway it may be necessary to relocate or remove navigation aids. This would need to be in consultation with the local Boating Safety Officer and RMS Navigation Aid Contractors. The cost for any relocation, removal or additional installation of navigation aids would be the responsibility of the Dredging Operator.

For more information, please contact Marcus Cahill, Manager Operations North on 0455 093 266.

Yours sincerely

Marcus Cahill
A/Manager Operations North
Operations and Compliance | Maritime

Our Reference: EF13/3750 SF18/44939 DOC18/408911
Contact: Geff Cramb
Date: 20 June 2018

Kim Bowra
Acting Manager Coastal Management Unit
Department of Industry
PO Box A290
Sydney South NSW 1232

Attention: Matthew Harry

Dear Ms Bowra

Re: Proposed Backpassing by Dredge – Tweed Sand Bypassing project

I refer to your correspondence dated 29 May 2018 providing a copy of a Review of Environmental Factors to carry out the Proposed Backpassing by Dredge activity, associated with the Tweed River Entrance Sand Bypassing Project (TRESBP).

Essentially the activity is the dredging of sand from the Tweed River mouth and transported by floating dredge for placement at two near-shore deposition areas at Letitia/Fingal Beach and Dreamtime Beach, New South Wales. In so far as the EPA is concerned, the documentation states:

- that an intention of the TRESBP is to continuously maintain the navigability of the Tweed River entrance;
- that the sand collection system and dredging of the Tweed River entrance by floating dredge are complementary and fundamental components of the same system;
- the back-passing by dredge is to continue in perpetuity;
- the Letitia/Fingal and Dreamtime Beach deposition areas have a 'filled' capacity of approximately 600,870 m^3;
- actual volumes of sand deposited annually in the two deposition areas will be an order of magnitude smaller than the 'filled' capacity (i.e. approximately 60,000 m^3);
- the possibility for increased turbidity, suspended solids and potential water contaminants in water sediments, waste materials, fuels and chemicals to be spilled during dredging, haulage and deposition;
- water testing at the deposition area at a frequency of 12 times per year (post deposition); and,
- an Environmental Impact Statement is not required.

The EPA also notes that the TRESBP:

- contract agreements allow for supplementary dredging and nourishment works to be carried out to clear the Tweed River entrance when required; and,
- Permanent Sand Bypassing System Components include Sand Removal Area Compartments A, B and C.

PO Box 498, Grafton NSW 2460
L2, 49 Victoria Street Grafton, NSW 2460
Tel: (02) 6640 2500 Fax: (02) 6640 2539
ABN 43 692 285 758
www.epa.nsw.gov.au

Tweed River Entrance Sand Bypassing Company Pty Ltd (TRESBC) currently holds Environment Protection Licence (EPL) 10432 with the EPA for the water-based extraction of 500,000 to 2,000,000 metres cubed (m^3) of material. The material extracted by a sand collection system is pumped via pipeline to four beach outlets in New South Wales and Queensland. It is understood that both the proposed floating dredge and the TRESBC are operating under the same project approval issued by the Minister in 1988 to operate the TRESBP, and that both the dredge and TRESBC are proposed to operate in proximity to each other.

At this stage the EPA has not provided comment on the proposed mitigation measures, and will do so at a later date when a final is provided.

With the above in mind, the EPA believes that the activity of dredging of sand from the Tweed River mouth for the TRESBP, is part of the same activity encompassed by EPL 10432. On this basis, the EPA would require TRESBC to complete and submit a 'Licence variation application – premises' form for assessment of the proposed activity to be added to EPL 10432 prior to works commencing.

If, however, you consider that the proposed dredging should not be incorporated into the licensed activities for TRESBC, the EPA will consider any further information provided from you.

Should you require any further information, please contact Geff Cramb on 02 6640 2510.

Yours sincerely

Janelle Bancroft
Acting Head, Environmental Management Unit
North Coast Region
Environment Protection Authority

Office of Environment & Heritage

Our Ref: DOC18/377688
Your Ref: DOC18/110775

NSW Department of Primary Industry
Coastal Assessment Unit
PO Box 624
Ballina NSW 2478

Attention: Mr Matthew Harry – Environmental Officer - Tweed Sand Bypass Project

Dear Mr Harry

Re: Proposed Tweed Sand Bypassing – Back-passing by Dredge Proposal

Thank you for your letter dated 29 May 2018 about the Tweed Sand Bypassing Project seeking comments from the Office of Environment and Heritage (OEH). I appreciate the opportunity to provide input.

We note that the proposal will be assessed pursuant to Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and the Department of Industry (DoI) is the determining authority.

The OEH has statutory responsibilities for biodiversity (including threatened species, populations, ecological communities, or their habitats), Aboriginal cultural heritage, historic heritage, OEH Estate, flooding, estuaries and coastal erosion.

We have reviewed the '*Review of Environmental Factors Tweed Sand Bypassing – Back-passing by Dredge, prepared Ardill Payne & Partners for NSW DPI – Crown Lands, dated December 2017*' and supporting documents and have no issues to raise about Aboriginal cultural heritage or flooding. However, several issues are apparent with the assessments for coastal processes, aquatic biodiversity, OEH Estate and historic heritage. Our detailed comments are provided in **Attachment 1** to this letter.

In summary, the OEH recommends that the proponent should:

1. Consider the possible benefits of a cost sharing arrangements with Tweed Shire Council and matching funding towards actions in the Coastal Zone Management Plan through the NSW Government's Coastal and Estuary Grants Program.

2. Revise the Review of Environmental Factors to address the legislative references, State Environmental Planning Policy (Coastal Management) 2018 and issues expressed regarding coastal processes, aquatic biodiversity, OEH Estate and Historic Heritage as per our recommendations listed in 2(a-j) of Attachment 1 to this letter.

Locked Bag 914 Coffs Harbour NSW 2450
Federation House, Level 8, 24 Moonee Street
Coffs Harbour NSW 2450
Tel: (02) 6659 8200 Fax: (02) 6659 8281
ABN 30 841 387 271
www.environment.nsw.gov.au

3. Revise the Aquatic Ecological Assessment to include additional information on aquatic biodiversity and OEH Estate as per our recommendations listed in 3(a-g) of Attachment 1 to this letter.

4. Provide the Operational Environmental Management Plan to the OEH for review.

If you have any further questions about this issue, Ms Rachel Binskin, Regional Operations Officer, Regional Operations, OEH, can be contacted on 6659 8247 or at rachel.binskin@environment.nsw.gov.au.

Yours sincerely

9 July 2018

RACHEL LONIE
A/Senior Team Leader Planning, North East Branch
Regional Operations

Contact officer: RACHEL BINSKIN
6659 8247

Enclosure: Attachment 1: Detailed OEH comments for the proposed Back-passing by Dredge – Tweed Sand Bypassing Project.

Attachment 1: Detailed OEH Comments - Back-passing by Dredge, Tweed Sand Bypassing Project

The Office of Environment and Heritage (OEH) has reviewed the documents provided by the NSW Department of Primary Industry - Lands (DPI). We provide the comments below relative to our statutory responsibilities on the proposed back-passing of dredged marine sand from the Tweed River to two depositional areas off Fingal and Dreamtime Beaches immediately south of Tweed Heads. We note that the proposal involves the maintenance of a navigable channel associated with the Tweed River Sandbar.

The documents reviewed include:

- *'Review of Environmental Factors Tweed Sand Bypassing – Back-passing by Dredge, prepared by Ardill Payne & Partners for NSW DPI Crown Lands, dated December 2017'* (REF),
- *'Aquatic Ecology Assessment for the Tweed Sand Backpassing –. Niche Environment and Heritage for Ardill Payne & Partners, dated November 2017'* (AEA),
- *'Tweed River Entrance Sand Bypassing Project – Backpass Deposition Areas Sediment Particle Size Distribution, Hydrosphere Consulting, dated May 2018'.*

The OEH does not oppose the proposed back passing of sand from the Tweed River entrance towards the south if all the issues and impacts are adequately considered. The proposal should not result in any significant impact to ecological, social or cultural values of the Tweed River, or Tweed coastline. We advise that several issues remain apparent with respect to the REF and the supporting documents, including deficiencies in the provision of information, scientific data, and assessment of impacts. These issues are outlined below relative to coastal processes, aquatic biodiversity, historic heritage and OEH Estate.

Coastal Processes

The OEH advises that an opportunity exists to use the sand dredged from the Tweed River entrance delta to nourish the Kingscliff Beach. This area has been subject to erosion cycles and coastal engineering intervention, including beach nourishment, for several years. The Tweed Shire Council recently adopted a Coastal Zone Management Plan (CZMP) for Kingscliff -Dreamtime Beach (at http://www.tweed.nsw.gov.au/item/1385), which includes an intention to source and deliver sand for beach nourishment directly.

This CZMP is currently being considered for certification under the (repealed) *Coastal Protection Act 1979*, and If certified, the council will be eligible for matching funding towards actions in the CZMP through the NSW Governments Coastal and Estuary Grants Program. We recommend that DPI Crown lands consider the possible benefits of this approach, which could include cost sharing arrangements. A report prepared for Tweed Shire Council entitled *Tweed River Sand Extraction and Delivery to Kingscliff Beach - Environmental Impact Statement* (KBR, 2010) investigates terrestrial based sand pumping from the Tweed River and provides the environmental and cost considerations. This could be considered as an option under this proposal.

The issues associated with coastal processes include:

- The lack of clarity on the total amount of sand to be mobilised. Currently the only description is within the AEA (page 9) which identifies a total volume of 600,870 m^3 of sand to be dredged from the Tweed River entrance delta and deposited on Fingal Beach (434,000 m^3) and Dreamtime Beach (166,870 m^3) by a Trailer Suction Hopper Dredge. The dredge described in the proposal has a hopper volume of 400 m^3. This implies at least 1,500 trips at full capacity, however the timeframe or operational period to deliver this volume of sand is not clear (i.e. months/years), or the time of the year, including anticipated ocean/weather conditions for the operation(s). This is critical information for understanding the possible impacts to various social and environmental values. More information should be provided on the operations as part of the REF.

- The potential to mobilise contaminates (including nutrients) within the estuarine sediments/sands. The AEA does recommend additional testing of the estuarine material prior to commencement of works, however this information should have been undertaken to inform the REF and the proposal's delivery.
- The potential to elevate turbidity and increase sedimentation above natural conditions as stated in Section 4.2.2 of the REF. This potential impact to aquatic biodiversity, especially sensitive habitats such as reef communities present within and radiating out from the deposition area. Insufficient information is provided on the direct and indirect nature of this impact, and there is no modelling provided on seasonal conditions, predominant ocean currents relative to known areas of high/sensitive aquatic biodiversity (i.e. reef communities), OEH Estate, or historic shipwrecks.
- The impacts to the visual and recreational public amenity of the coastline. The assumption is the operations would occur during good weather conditions, and the impact of the dredger on visual and recreational amenity (e.g. fishing, diving, boating) has not been sufficiently addressed given the proximity of the proposed operations to beaches, wrecks, recreational areas, and the Cook Island Aquatic Reserve. The REF should also consider potential issues with public safety, relative to these recreational values during operations.

Aquatic biodiversity

On review of the AEA and REF its appears that, apart from a desktop assessment, no additional aquatic biodiversity survey has been undertaken to inform the assessment of impacts associated with this proposal. We recognise that Department of Primary Industries - Fisheries will provide comment relative to the *Fisheries Management Act 1994* on the marine based ecosystems impacted by this proposal. However, we make the following comments on the documents provided pursuant to the *Biodiversity Conservation Act 2016* (BC Act 2016), and the *National Parks and Wildlife Act 1974* (NPWS Act 1974).

The issues associated with aquatic biodiversity assessment include:

- The use of inconsistent statutory references. The REF references ecological assessment under both the BC Act 2016 and the (repealed) *Threatened Species Conservation Act 1995*. The AEA has assessed the proposal's impacts on biodiversity under the BC Act 2016, however it has failed to consider Part 7 of that Act relative to threatened entities known to occur.
- The use of the draft Coastal Management SEPP. We recommend using the SEPP Coastal Management (2018) in the REF to consider possible adverse impacts on the Coastal Environment Area, pursuant to Part 2, Division 3, Clause 13, as the deposition areas are within this area. The AEA and REF have not sufficiently considered adverse impacts on biophysical, hydrological and ecological environments or the adverse impacts on geomorphological features, coastal processes, impacts on water quality or aquatic biodiversity or their habitats in accordance with the SEPP.
- Inconsistent descriptions and assessment of impacts on aquatic biodiversity values, especially benthic communities. For example, the potential detrimental impacts as identified in Section 5.1 of the AEA are dismissed without justification as part of Section 4.2.4 of the REF.
- The failure to acknowledge cumulative impacts on aquatic ecosystems associated with the proposal, in Section 4.2.12 of the REF.
- The limited field survey data used within the AEA to assess aquatic biodiversity values, especially threatened entities present, and describe / confirm benthic communities (habitats) in the necessary detail to support an adequate assessment. The AEA appears not to have considered the likelihood or magnitude of potential adverse impacts on aquatic biodiversity values, given no modelling or scenarios are provided to adequately assess the impacts of repeat sediment loading (smothering) episodes. No information is provided on the potential for sediment migration at a rate that may far exceed natural rates, volumes, or depths. Due to the limitations of data presented we would advise that the impacts of the proposal on threatened entities, their habitats, or sensitive benthic communities cannot be justifiably gauged.

- The proposed monitoring program is unclear. The AEA confirms the need for monitoring, however it remains unclear if the monitoring will be supported by any adaptive management or stop work parameters, especially where detrimental impacts are detected. We advise that impacts such as turbidity, sedimentation and increased contaminants associated with the deposition of marine sands on the benthic reef communities of Cook Island Aquatic Reserve, the Cook Island Nature reserve or the habitats of threatened entities listed under the BC Act remain outstanding. We do acknowledge that Section 5.1 of the REF recommends several safeguard distances to be established between OEH Estate and threatened/migratory entities (such as Whales, dolphins and seabirds etc.) from deposition operations. However, it remains unclear how these have been calculated, will be applied, monitored and included in any operational reporting. It also remains unclear how these safeguards will affect operations and if any contingency planning is or will be in place into the future.

OEH Estate

With respect to the Cook Island Nature Reserve, as reserved under the *National Parks and Wildlife Act 1974,* and the surrounding marine protected area of the Cook Island Aquatic Reserve. We note that the REF currently states that the proposal deposition areas are separated from and will not impact any OEH Estate. However, the AEA lists several detrimental impacts on the surrounding aquatic biodiversity values. The OEH does not support any proposal or operations that may detrimentally impact on OEH estate or the surrounding aquatic reserve.

The issues associated with the OEH Estate, include:

- The lack of information on potential indirect impacts of the dredging operations on the Tweed River estuary, especially the OEH estate - Ukerebagh Nature Reserve and the shore/wading bird habitat associated with the reserve.
- The lack of justifiable information on potential water quality impacts relative to the reserves. We note that the depositional areas associated with the proposal are close to the aquatic reserve boundary which surrounds OEH estate as shown in Figure 2 of the AEA. The AEA also outlines several impacts which may affect the aquatic reserve's values, such as smothering benthic communities, increased turbidity (suspended solids), and contaminants (including nutrients), as well as introduction of invasive/exotic species into the reserve. Section 5.7.8 – Corals of the AEA clearly states that *'the magnitude of impacts on sedimentation and poor water quality on corals remain high'*. These impacts are dismissed by the REF without any justification.
- The absence of aquatic biodiversity data. It is noted that the project relies on the Kirra Reef Biota Monitoring Project 2017, however that information is not included as part of the AEA. Although the AEA does identify dominant benthic communities, it provides no detail of their exact location or impacts relative to the deposition areas or resulting sediment plumes. The AEA has not addressed the influence of wind dynamics and currents on sand deposition and transport relative to the aquatic reserve or the shoreline of the Cook Island Nature Reserve.
- The application of only a 100m generic depositional buffer from Cook Island Aquatic Reserve (which surrounds the Cook Island Nature Reserve), and the 300m buffer from nesting sites of threatened & migratory species (present within Cook Island Nature Reserve) are not clearly justified in Section 5.1 of the REF or depicted within the figures supplied. These buffers appear not to be supported by any data or spatial modelling associated with known or potential impacts of the proposed operations. Therefore, we advise that it cannot be demonstrated that it will avoid or significantly minimise impacts to OEH estate, sensitive ecosystems, threatened entities or their habitats.
- The absence of specific detail within the REF contingency planning for the proposal relative to the reserves. This does not appear to reflect the AEA recommendations.

Historic Heritage

As noted in the REF, two protected ship wrecks have been identified near the proposed deposition areas. Historic Ship Wrecks are protected under the *Heritage Act 1977.*

The issues associated with Historic Heritage include:

- Limited information on the potential impacts of this proposal on the historic, scientific or recreational values of the "Dellie" (Site ID 1563) or the "Fido" (Site ID 1443) and no evidence of consultation with the OEH Heritage Division in the REF.
- Limited justification on the adequacy of the proposed 100m safeguard buffer between proposed depositional sites as set out in Section 5 of the REF and the ship wrecks. It is not clear whether the buffer considered predominant ocean currents, and sediment migration resulting from the proposal's operation.
- Lack of monitoring proposed for the shipwrecks.

OEH Recommendations

The OEH recommends that the proponent should:

1. Consider the possible benefits of a cost sharing arrangements with Tweed Shire Council and matching funding towards actions in the Coastal Zone Management Plan through the NSW Governments Coastal and Estuary Grants Program, in accordance with the Tweed '*Tweed River Sand Extraction and Delivery to Kingscliff Beach - Environmental Impact Statement* (KBR, 2010)'.

2. Revise the Review of Environmental Factors to:
   a. update the legislative references to ensure consistencies between all the documents provided relative to the *Biodiversity Conservation Act 2016,* (repealed) *Threatened Species Conservation Act 1995* and the amended *Environmental Planning & Assessment Act 1979.*
   b. include the State Environmental Planning Policy (Coastal Management) 2018 into s3.1, and consider possible adverse impacts on the Coastal Environment Area pursuant to Part 2, Division 3, Clause 13. This should include an assessment of adverse impacts on the features as outlined in the SEPP.
   c. assess potential impacts on the ship wrecks pursuant to the *Heritage Act 1977*. Further advice can be obtained from the OEH Heritage Division directly on heritage@heritage.nsw.gov.au or (02) 9873 8575.
   d. address the inconsistencies with the Aquatic Ecological Assessment Report relative to known and potential impacts on aquatic biodiversity.
   e. quantify the volume of sand to be mobilised, the methodology and timeframes (or scheduling) involved, including contingency planning to address ocean and weather conditions associated with the proposal's operation.
   f. provide the baseline sediment contamination levels as recommended in Section 6.2 of the AEA, and ensure the baseline is undertaken to inform the water quality impact control measures as outlined in Section 5.1 of the REF. This should include additional information on the monitoring methodology and reporting requirements.
   g. consider visual, recreational (e.g. beach use, fishing, diving, boating) amenity, and public safety, especially with respect to recreational values of the Cook Island Aquatic Reserve and historic ship wrecks, given the proximity of the proposed operations.
   h. include figures which clearly depict all features such as biodiversity, historic heritage and OEH Estate relative to this proposal, including overlays showing the distribution of benthic aquatic biodiversity at radiuses of 100, 200 and 300 m out from the deposition area (point).
   i. provide a spatial-conceptual model of the operations, which includes, but is not limited to, dredging and deposition locations, navigation routes, known or anticipated sediment transport pathways, and predominant currents.

j. identify key monitoring priorities, establish baseline information for those priorities, methods, frequencies and reporting. The REF should also identify adaptive management (including triggers), contingency planning and reporting requirements.

3. Revise the Aquatic Ecological Assessment to:

   a. address data deficiencies associated with aquatic biodiversity values, undertake a gap analysis of the available data, and confirm what additional field survey may be required. The AEA should describe the survey methodology, intensity, timing and location, note if sampling sites are to be used for future monitoring.

   b. describe ecosystems that may be impacted directly at the extraction and depositional area of operations and likely sediment migration and transport pathways relative to the radiuses of 100, 200 and 300 m out from the initial source.

   c. provide a revised figure of the aquatic biodiversity values present and present the data within the AEA.

   d. assess direct, indirect and cumulative impacts associated with the deposition and repeat sedimentation episodes, include migration of sediments on ecosystems, especially those associated with the Cook Island Nature Reserve (and surrounding aquatic reserve). The review should consider the dynamics of wind, currents and its influence on sand deposition and transport.

   e. identify how these impacts will be avoided or minimised, including details about alternative options considered and how minimisation arrangements will be guaranteed. This should include justification of the generic buffers applied, especially those associated with the Cook Island Nature Reserve, and the Cook Island Aquatic Reserve. The AEA should demonstrate the principles of avoid or minimise impacts, and that the actions proposed are justified.

   f. include as part of the monitoring program, sufficient baseline data on aquatic biodiversity, especially within the aquatic reserve, including potential impact or exposed areas and possible control sites. The monitoring should include, but not be restricted to:

      i. Water quality (turbidity and potential contaminants)
      ii. Sedimentation
      iii. Changes to benthic communities/ aquatic biodiversity composition and distribution.
      iv. Benthic community recovery

   g. consult directly with the National Parks and Wildlife - Tweed/Byron Area Manager, Ms Sue Walker, prior to reviewing the AEA and drafting the Operational Environmental Management Plan relative to the Cook Island and Ukerebagh Nature Reserves. Ms Walker can be contacted by phone on (02) 6620 9304 or via email at sue.walker@environment.nsw.gov.au.

4. Provide the detailed Operational Environmental Management Plan to the OEH for review, including evidence that consultation with the National Parks & Wildlife and the OEH Heritage Division has occurred in the drafting of the avoid or minimise measures for the operation of this proposal.

NSW GOVERNMENT | Office of Environment & Heritage

Our Ref: DOC18/751638
Your Ref: CM9 Ref: 18/195002

NSW Department of Industry
Coastal Assessment Unit
PO Box 624
Ballina NSW 2478

Attention: Mr Matthew Harry – Environmental Officer – Tweed Sand Bypass Project

Dear Mr Harry

Re: Proposed Tweed Sand Bypassing – Back-passing by Dredge Proposal

Thank you for your letter dated 12 September 2018 about the Department of Industry (DOI) response to the Office of Environment and Heritage (OEH) recommendations regarding the *Tweed Sand Bypassing - Back-passing by Dredge* Review of Environmental Factors (REF). I appreciate the opportunity to provide input.

We have reviewed the DOI responses (marked in red) which have been provided prior to issuing the final REF in October 2018 and provide detailed comments on these in **Attachment 1** to this letter.

The OEH will provide comments on the revised REF once it has been updated to address all the relevant state and local government authority responses.

In summary, the OEH recommends that:

1. The REF should be amended to address the matters set out in Attachment 1 to this letter
2. The amended REF be provided to the OEH for comment, along with a draft Environmental Management Plan that will be used to monitor the operations.

If you have any further questions about this issue, Ms Rachel Lonie, Senior Conservation Planning Officer, Conservation and Regional Delivery, OEH, can be contacted on 6650 7130 or at Rachel.Lonie@environment.nsw.gov.au.

Yours sincerely

16 October 2018

DIMITRI YOUNG
Senior Team Leader Planning, North East Branch
Conservation and Regional Delivery

Enclosure: Attachment 1: Detailed OEH Comments – Proposed Tweed Sand Bypassing – Back-passing by Dredge Proposal

Locked Bag 914 Coffs Harbour NSW 2450
Federation House, Level 8, 24 Moonee Street
Coffs Harbour NSW 2450
Tel: (02) 6659 8200 Fax: (02) 6659 8281
ABN 30 841 387 271
www.environment.nsw.gov.au

Attachment 1: Detailed OEH Comments – DOI response to OEH issues regarding the proposed Tweed Sand Bypassing – Back-passing by Dredge Proposal

OEH comment	DOI response	OEH response
1. Consider the possible benefits of a cost sharing arrangements with Tweed Shire Council and matching funding towards actions in the Coastal Zone Management Plan through the NSW Governments Coastal and Estuary Grants Program, in accordance with the Tweed *'Tweed River Sand Extraction and Delivery to Kingscliff Beach - Environmental Impact Statement* (KBR, 2010)'.	Cost sharing arrangements with Tweed Shire Council (TSC) during TSB dredging or sand placement activities have not been considered in this REF as it is outside the scope of the report and should be explored through formal TSB collaborative forums with TSC. TSC is currently undertaking a Coastal Management Program for Fingal, including southern Letitia; upon completion of this, potential partnering arrangements can be explored.	**Noted.**
2. Revise the Review of Environmental Factors to: a. update the legislative references to ensure consistencies between all the documents provided relative to the Biodiversity Conservation Act 2016, (repealed) *Threatened Species Conservation Act 1995 and the amended Environmental Planning & Assessment Act 1979*.	APP to update REF.	**OEH will provide comments on the updated REF.**
b. Include the State Environmental Planning Policy (Coastal Management) 2018 into s3.1, and consider possible adverse impacts on the Coastal Environment Area pursuant to Part 2, Division 3, Clause 13. This should include an assessment of adverse impacts on the features as outlined in the SEPP.	It is likely that the SEPP clause relating to development on land within the coastal environment area is irrelevant as the proposed activity contributes to beach nourishment (i.e. coastal protection works without development consent). APP to address and update REF.	**The beach nourishment area (including the offshore areas used for sand deposition and the target adjoining beaches) are part of a Coastal Environment Area and a Coastal Use Area as defined in the Coastal Management SEPP.**

OEH comment	DOI response	OEH response
		Part 3 Clause 19 (2) of the Coastal Management SEPP allows coastal protection works to be carried out on land to which this Policy applies by or on behalf of a public authority without development consent if the works are beach nourishment. **We acknowledge DOI is therefore not required to consider the Coastal Management SEPP but we strongly advise the APP report consider the impacts on the items listed in the Coastal Management SEPP, including:** • **Division 3 Coastal Environment Area points 1 and 2.** • **Division 4 Coastal Use Area point 1.** **OEH will provide comments on the updated REF.**
c. Assess potential impacts on the ship wrecks pursuant to the Heritage Act 1977. Further advice can be obtained from the OEH Heritage Division directly on heritage@heritage.nsw.gov.au or (02) 9873 8575.	Although an assessment was made by APP and included in the REF, DOI will contact the Heritage Branch of OEH providing details on the proposed backpass activity, outline the potential impacts of the activity and seek their support of the REF.	**Noted. The Heritage Division within the Office of Environment and Heritage is the appropriate contact for this matter.**
d. Address the inconsistencies with the Aquatic Ecological Assessment Report relative to known and potential impacts on aquatic biodiversity.	APP to update where relevant as per the comments on page 5 of OEH's letter. Justification is required for some statements relating to the potential detrimental impacts of the activity.	**The Aquatic Ecology Assessment (AEA) identifies that the proposed activity <u>may</u> result in increased turbidity (and associated impacts including on coral within the aquatic reserve), noise which is likely to affect foraging for seabirds, and breeding and foraging for shorebirds. Also, that turtles are at risk of boat strike, entrapment and noise affecting foraging.** **Appendix 2 of the AEA considers significant impact matters and concludes that impacts will be short term, impact on a small area and the relevant animals have a wide habitat/foraging area. Also, that the impacted habitat is likely to be confined to soft sediment habitat and there is only minimal potential for impacts on the Black Rockcod and Grey Nurse Shark and the habitat is marginal foraging habitat only. However, this assessment is not explained in the REF.**

OEH comment	DOI response	OEH response
		We request that these REF responses be elaborated on to describe what the positive impacts would be and how the potential negative impacts have been considered and where necessary mitigated.
e. Quantify the volume of sand to be mobilised, the methodology and timeframes (or scheduling) involved, including contingency planning to address ocean and weather conditions associated with the proposal's operation.	DOI to provide additional details regarding the proposed dredge/placement methodology, APP to update REF. It is noted that the REF is not clear in nominating an annual volume of sand to be placed in the deposition areas leading to an assumption that over 500,000m3 could be dredged/placed in one backpass campaign. Whilst the receiving capacities of the nominated deposition areas are relatively large, the annual volume is significantly less at around 20,000m3.	**Advice on annual volumes of sand is noted. Please include details of volumes of sand to be mobilised, methodology, time frames and contingency plans in the REF as requested.**
f. Provide the baseline sediment contamination levels as recommended in Section 6.2 of the AEA, and ensure the baseline is undertaken to inform the water quality impact control measures as outlined in Section 5.1 of the REF. This should include additional information on the monitoring methodology and reporting requirements.	Baseline data is required prior to undertaking the proposed activity. APP to add to the REF as part of the monitoring requirements.	**OEH will provide comments on the updated REF.**
g. Consider visual, recreational (e.g. beach use, fishing, diving, boating) amenity, and public safety, especially with respect to recreational values of the Cook Island Aquatic Reserve and historic ship wrecks, given the proximity of the proposed operations.	It is noted that these issues are acknowledged in the draft REF. Consider OEH guidelines on visual amenity. TSB can demonstrate that the above impacts are currently considered across the whole project through regular Advisory Committee & Community (ACC) meetings where project activities, environmental monitoring data and community issues are discussed. This includes consultation with community stakeholders on a range of potential impacts as listed above. APP to include details in the REF	**These issues are not addressed in the REF. For example, the REF states:** **"4.2.10 Visual** **There will not be any resultant visual impacts from the proposed deposition."** **Also, under 3.3 (d) the REF states in relation to any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality that the impact will be positive there will be no adverse impacts on the aesthetics and environmental quality of the locality.**

OEH comment	DOI response	OEH response
		These statements are not supported by adequate justification. **Diving and recreational or professional fishing are not mentioned in the REF and supporting report. The OEH requests that there be discussion on the possible impacts on diving and recreational or professional fishing particularly on Cook Island. Some form of consultation with local stakeholders of the above industries (diving, fishing) should be included.**
h. Include figures which clearly depict all features such as biodiversity, historic heritage and OEH Estate relative to this proposal, including overlays showing the distribution of benthic aquatic biodiversity at radiuses of 100, 200 and 300 m out from the deposition area (point).	APP to update REF.	**OEH will provide comments on the updated REF.**
i. Provide a spatial-conceptual model of the operations, which includes, but is not limited to, dredging and deposition locations, navigation routes, known or anticipated sediment transport pathways, and predominant currents.	DOI to provide information on sediment transport pathways. Dredge operation details will be as per the methodology to be provided for recommendation 2.e.	**Please update the REF to include a spatial conceptual model which includes dredging and deposition locations, navigation routes, known or anticipated sediment transport pathways, and predominant currents and diving sites.**
j. Identify key monitoring priorities, establish baseline information for those priorities, methods, frequencies and reporting. The REF should also identify adaptive management (including triggers), contingency planning and reporting requirements.	Dredge operator will have their own permit conditions that would address many of these concerns. DOI to source an example of these conditions to demonstrate how the operations are managed.	**Please provide the OEH with an example of the EMP which will be used to monitor the operations.**
3. Revise the Aquatic Ecological Assessment to: a. address data deficiencies associated with aquatic biodiversity values, undertake a gap analysis of the available data, and confirm what additional field survey may be required. The AEA should describe the survey methodology,	DOI's understanding is that the desktop study is sufficient for the sand volumes to be dredged/placed. APP to address in updated REF.	**Please elaborate on this point in the updated REF.**

OEH comment	DOI response	OEH response
intensity, timing and location, note if sampling sites are to be used for future monitoring.		
b. describe ecosystems that may be impacted directly at the extraction and depositional area of operations and likely sediment migration and transport pathways relative to the radiuses of 100, 200 and 300 m out from the initial source.	To be considered as part of the update to address recommendation 2.h.	**OEH will provide comments on the updated REF.**
c. provide a revised figure of the aquatic biodiversity values present and present the data within the AEA.	NSW Parks and Wildlife to clarify these requirements considering the content of the existing desktop AEA and the recent information that has been provided by DOI regarding annual dredge/placement sand volumes.	**The AEA erroneously states that neither green nor loggerhead turtles nest as far south as Tweed, when both species nest on the Tweed coast every summer. NPWS advises that last summer a green turtle nested on Fingal Beach north of the headland. Changes to the amount and types of sediments may impact on the success rate of sea turtle nests. This may or may not be a positive impact as sand nourishment may be beneficial depending on factors such as sand particle size, area of deposition and sand colour.** **Contrary to what is stated in the AEA, humpback whales do calve in NSW waters, including off the Tweed coast, in increasing numbers proportionate to their annual increase in population. There is the possibility that humpback whales could calf in this area at the same time as the dredging activity and potential impacts and mitigation measures should be considered in the REF.** **The bush stone-curlew is unlikely to be impacted by the proposed activity, but beach stone-curlews *(Esacus magnirostris)* could be. The birds have been recorded foraging on the shoreline. The endangered little tern has been recorded on Cook Island and would forage in the study area. Pied oystercatchers also forage in the area and the REF states that there is an unlikely impact on the species but does not provide any justification.** **APP should obtain a recent list of BioNet records for threatened and migratory species from the OEH Wildlife Data Unit. This should include an "all records" search to obtain**

OEH comment	DOI response	OEH response
		quarantined records which will include the records for last summer's sea turtle nesting. These data should be provided in the REF along with a map showing Bionet records in relation to the Cook Island Nature Reserve, Cook Island Aquatic Reserve, and the activity (such as nesting and foraging). **Once the records are obtained the consultant should contact the local NPWS Office to ensure that all locally known species are included.** **All likely and known threatened and migratory species including those referred to above should be the subject of a Test of Significance under Section 7.3 of the *Biodiversity Conservation Act 2016* completed in accordance with the Test of Significance Guidelines gazetted by the Minister for the Environment. (https://www.environment.nsw.gov.au/biodiversity/threatened-species-test-of-significance.htm)**
d. assess direct, indirect and cumulative impacts associated with the deposition and repeat sedimentation episodes, include migration of sediments on ecosystems, especially those associated with the Cook Island Nature Reserve (and surrounding aquatic reserve). The review should consider the dynamics of wind, currents and its influence on sand deposition and transport.	APP to address these potential impacts by considering advice that is to be provided by DOI regarding sediment transport processes and the volume of sand to be place in any single campaign. It is likely that cumulative impacts will be minimal due to the relatively small placement volumes compared to the natural sediment transport rate and the receiving capacity of the deposition areas.	**Noted. OEH will provide comments on the updated REF.**
e. identify how these impacts will be avoided or minimised, including details about alternative options considered and how minimisation arrangements will be guaranteed. This should include justification of the generic buffers applied, especially those associated with the Cook Island Nature Reserve, and the Cook Island Aquatic Reserve. The AEA should	APP to clarify justification of the 100m buffer around the Cook Island Aquatic Reserve (related to vessel navigation only, buffer is going above and beyond exclusion zone requirements). It is likely that impacts referred to will be minimised as per the response that will be provided for recommendation 3.d.	**Noted. OEH will provide comments on the updated REF.**

OEH comment	DOI response	OEH response
demonstrate the principles of avoid or minimise impacts, and that the actions proposed are justified.		
f. include as part of the monitoring program, sufficient baseline data on aquatic biodiversity, especially within the aquatic reserve, including potential impact or exposed areas and possible control sites. The monitoring should include, but not be restricted to: i. Water quality (turbidity and potential contaminants) ii. Sedimentation iii. Changes to benthic communities/ aquatic biodiversity composition and distribution. iv. Benthic community recovery	APP to investigate whether TSB's existing biota monitoring activities can satisfy the details of this recommendation.	**Noted. OEH will provide comments on the updated REF.**
g. consult directly with the National Parks and Wildlife -Tweed/Byron Area Manager, Ms Sue Walker, prior to reviewing the AEA and drafting the Operational Environmental Management Plan relative to the Cook Island and Ukerebagh Nature Reserves. Ms Walker can be contacted by phone on (02) 6620 9304 or via email at sue.walker@environment.nsw.gov.au.	This recommendation is not relevant to the proposed activities of the REF. Dredging of the Tweed River entrance will be carried out as per the existing project approvals.	**It is noted that the proposed activity is for deposition of material and not dredging of the Tweed River entrance which has already been assessed and approved. However, the REF needs to be explicit that there will be no impact on NPWS estate from this activity, including Ukerebagh Nature Reserve (NR) and on its natural and cultural heritage values. Reference should be made to the plans of management for both NRs.** **We note that on page 14 of the REF the Cook Island Aquatic Reserve is mentioned in the NPWS section. The Aquatic Reserve is managed by DoI Fisheries, not NPWS, and should be referred to as such throughout the REF and attachments.** **Cook Island Nature Reserve is an important breeding and roosting site for shorebirds and seabirds protected by international agreements ratified under the EPPC Act such as CAMBA, JAMBA and ROKAMBA. The ocean and reefs surrounding Cook Island Nature Reserve provide feeding habitat for these species. Impacts arising from the activity on these values must be fully addressed.**

OEH comment	DOI response	OEH response
		Cook Island, Fingal Peninsular and the Giants Causeway are all significant to the local Aboriginal people who should be consulted about the proposed activity. This could include notification in the local newspaper and local shops to advise on the proposed activity.
4. Provide the detailed Operational Environmental Management Plan to the OEH for review, including evidence that consultation with the National Parks & Wildlife and the OEH Heritage Division has occurred in the drafting of the avoid or minimise measures for the operation of this proposal.	EMP's for the proposed activity are the responsibility of the dredge operator. DOI can source an example of the EMP and/or OEMP. The dredge operator must also comply with conditions of and Environmental Protection License issued through EPA.	**Please provide the OEH with an example of the EMP which will be used to monitor the operations.**

TWEEDSAND BYPASSING

Advisory Committee and Community Meeting

1st August 2018

Summary of Discussions – Key Issues & Sand Movements

Community Beach and Entrance Reports – Reports received as follows;

Rainbow Bay SLSC - Over the last 6 months, a large amount of sand has built up around Snapper Rocks, Little Mali and Rainbow Bay. The issue to consider is that Rainbow Bay is no longer a bay. In its current state, it does not provide safety and protection for swimmers.

North Kirra SLSC - Conditions generally good. No notable change in beach conditions.

Bilinga SLSC - Beach conditions have been relatively stable with good beach access. Some sand loss over the Summer but it has now returned.

Tugun SLSC - The condition of Tugun beach over the last six months has been good. During summer there were a few topographic rips, but the beach has been largely left in a good condition with plenty of sand.

Dbah Boardriders - Conditions have been generally good.

Volunteer Marine Rescue - No reports of any major incidents. Lots of crossings. Generally calmer conditions resulting in favourable entrance conditions.

Tourism (Ocean dive) - Over the last six months the weather has been quiet good with mainly minimal swell. Unfortunately when we do get some swell we have still been cancelling trips due to it being unsafe to cross the bar due to there being no straight channel especially on the runout tide with swell height anything over 1.4 m on the average on the wave rider.

Sand Placement / Pumping – Approximately 213,310 m^3 of sand was pumped to Snapper Rocks East during the period January 2018 to end July 2018. Calm conditions have generally resulted in lower pumping volumes. This was illustrated via comparison of 2018 volumes vs average monthly volumes (between 2013-2017). It was noted the last dredge campaign concluded in August 2017 and that no further dredging works have taken place since. It was also noted the last Duranbah campaign was completed in July 2017. Information requested from community regarding infill rates from dredge areas, this will be provided at the next meeting.

Wave Conditions – Wave conditions were presented and it was noted that generally calmer conditions have occurred between February and July 2018. Only one event occurred during this period with a significant wave height exceeding 3m.

Entrance Conditions and Usage - Entrance survey of 13 July 2018 currently shows a clear navigational channel. A small shoal has developed off the end of the southern training wall. Entrance usage (via VMR records) has shown the number of entrance crossings to be consistent with the 12 month average.

Beach Conditions - Duranbah aerials (October 2017, January 2018, March 2018 and July 2018) showed the maintenance of reasonable and uniform beach width and the migration of a rip cell from the center of the beach to the north. Rainbow bay for the same period showed the formation of an inshore lagoon at Rainbow Bay. Greenmount showed a reduction in beach width, however still with reasonable amenity. Kirra beach has maintained a good beach width across this period. Information requested from community regarding monitoring of beach conditions at Fingal. Aerial photography of Fingal and a summary of beach conditions will be presented at the next meeting.

Surf Amenity - Although not many large swell events have occurred, surf quality has generally been good with consistent swell between 1 and 2m and favourable conditions.

Communications – Communications have been progressing well with good traffic continuing to be experienced on the Tweed Sand Bypassing Instagram page and users of the Tweed Sand Bypassing App. The project had a presence at the 2018 Quiksilver Pro Gold Coast with a number of Sand magazines and A5 flyers distributed to the public. A video was posted on Stab Magazine's website featuring the TRESBCo Operations Manager and vision of the sand pumping facility.

TSB Projects – Backpass by dredge deposition areas are continuing to be progressed, with Review of Environmental Factors currently being assessed by relevant regulatory authorities. Sediment Transport Information System (STIS) projects are actively continuing, with STIS002 being a tool to be used by governments when planning dredging and nourishment campaigns. An update on STIS002 (an investigation into trapping and energy efficiency) was also provided.

Appendix H
AHIMS search and Extensive search results

Office of Environment & Heritage
NSW GOVERNMENT

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : Backpassing REF

Client Service ID : 319408

Department of Industry - Lands

437 Hunter St
Newcastle New South Wales 2300

Attention: Isaac Smith

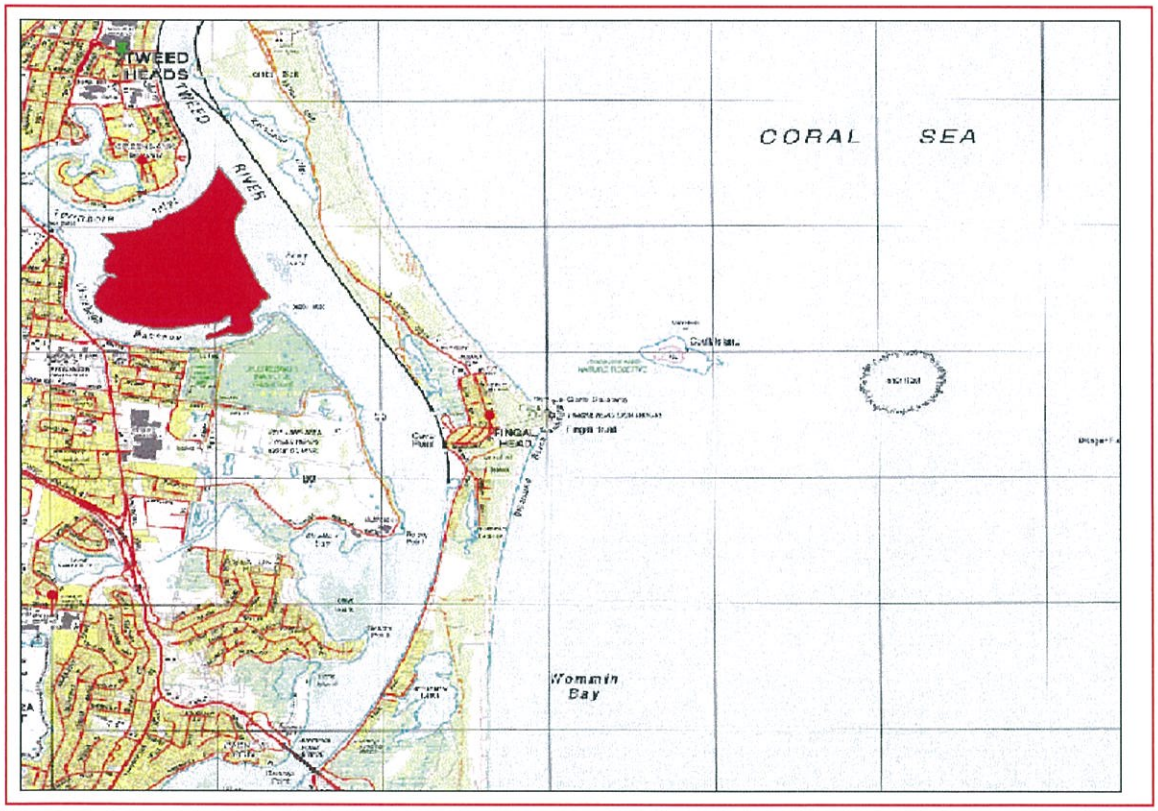
Email: isaac.smith@crownland.nsw.gov.au

Date: 19 December 2017

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -28.2143, 153.5484 - Lat, Long To : -28.1846, 153.5956 with a Buffer of 1000 meters, conducted by Isaac Smith on 19 December 2017.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

33	Aboriginal sites are recorded in or near the above location.
1	Aboriginal places have been declared in or near the above location. *

ID	Aboriginal Place Name
47	Ukerebagh Island

Office of Environment & Heritage

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Backpassing REF

Client Service ID : 319410

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
04-2-0009	South Tweed Heads Bora Ring, BMP-05-0164	AGD	56	553830	6880450	Open site	Valid	Shell : -, Artefact : -, Ceremonial Ring (Stone or Earth) : -	Bora/Ceremonial,Midden	206
	Contact Tweed Byron LALC	**Recorders**	Harry Creamer,L Gregg,Mr.R McKinney,Mr.Ian Fox					**Permits**		
04-2-0071	Sexton Hill midden	AGD	56	553960	6879230	Open site	Valid	Shell : -, Artefact : -	Midden	2522,2526,2600
	Contact	**Recorders**	Mr.John Appleton,F Roberts					**Permits**	410	
04-1-0022	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact Tweed Byron LALC	**Recorders**	Unknown Author,Mr.Ian Fox					**Permits**		
04-1-0024	Banora Point	AGD	56	554300	6878000	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	**Recorders**	Unknown Author					**Permits**		
04-2-0010	Fingal Point	AGD	56	555400	6880000	Open site	Valid	Burial : -, Artefact : -	Burial/s	100165
	Contact	**Recorders**	Isabel McBryde					**Permits**		
04-2-0011	Fingal Point;Fingal;	AGD	56	555400	6880000	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	**Recorders**	O.B Pryor					**Permits**	4098	
04-2-0014	Ukerebagh Island Midden	AGD	56	553700	6880800	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	**Recorders**	Unknown Author					**Permits**		
04-2-0017	Barney's Point, BMP-05-0165	AGD	56	553900	6878050	Open site	Valid	Shell : -, Artefact : -	Midden	611
	Contact Tweed Byron LALC	**Recorders**	Mr.Adrian Piper,Mr.Ian Fox					**Permits**		
04-2-0032	Greenbank Island;Tweed Heads;	AGD	56	553220	6882570	Open site	Valid	Shell : -, Artefact : -	Midden	56,1130
	Contact	**Recorders**	C Paul					**Permits**		
04-2-0076	Fingal Head	AGD	56	555350	6880600	Open site	Valid	Artefact : -, Shell : -	Open Camp Site	
	Contact	**Recorders**	Mr.Adrian Piper					**Permits**		
04-2-0077	Fingal Head	AGD	56	555400	6880290	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	**Recorders**	Mr.Adrian Piper					**Permits**		
04-2-0078	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact Tweed Byron LALC	**Recorders**	Mr.Adrian Piper,Mr.Ian Fox					**Permits**		
04-2-0013	Fingal Head Aboriginal Cemetery	AGD	56	555375	6880970	Open site	Valid	Burial : -	Burial/s	
	Contact	**Recorders**	Harry Creamer,Harry Creamer,Ray Kelly,Gerry Bostock					**Permits**		
04-2-0016	Ukerebagh Island, BMP-05-0154	AGD	56	553800	6881700	Open site	Valid	Aboriginal Ceremony and Dreaming : -	Natural Mythological (Ritual)	
	Contact Tweed Byron LALC	**Recorders**	Harry Creamer,Mr.Ian Fox					**Permits**		
04-2-0130	Fingal Point Quarry	AGD	56	555598	6880087	Open site	Valid	Habitation Structure : -		

Report generated by AHIMS Web Service on 19/12/2017 for Isaac Smith for the following area at Lat, Long From : -28.2143, 153.5484 - Lat, Long To : -28.1846, 153.5956 with a Buffer of 1000 meters. Additional Info : REF Information. Number of Aboriginal sites and Aboriginal objects found is 33

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Backpassing REF

Client Service ID : 319410

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	**Recorders**	Ms.Katrina Stankowski					**Permits**		
04-2-0143	Ukerebach Island	AGD	56	553831	6881821	Open site	Valid	Aboriginal Resource and Gathering : -, Habitation Structure : -, Potential Archaeological Deposit (PAD) : -		
	Contact T Russell	**Recorders**	Ms.Katrina Stankowski					**Permits**		
04-2-0144	Fingal Point Community	AGD	56	555026	6881138	Open site	Valid	Burial : -, Habitation Structure : -		
	Contact T Russell	**Recorders**	Ms.Katrina Stankowski					**Permits**		
04-2-0162	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact Searle	**Recorders**	Mr.Ian Fox					**Permits**		
04-2-0165	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact Searle	**Recorders**	Mr.Ian Fox					**Permits**		
04-2-0166	kinnear Aboriginal Midden Site	AGD	56	554149	6878326	Open site	Valid	Shell : 1		
	Contact T Russell	**Recorders**	Bonhomme Craib & Associates					**Permits**		
04-2-0191	Tweed City North, Kirkwood Rd	GDA	56	553703	6880609	Open site	Valid	Potential Archaeological Deposit (PAD) : -		103037
	Contact	**Recorders**	Mr.Tim Robins					**Permits**	3650	
04-2-0194	Faux Park Midden	GDA	56	553074	6881900	Open site	Valid	Artefact : -, Non-Human Bone and Organic Material : -, Potential Archaeological Deposit (PAD) : -, Shell : -		
	Contact	**Recorders**	Mr.Oliver Brown					**Permits**	3796	
04-2-0200	Fingal Head Cemetary & Graves	GDA	56	555345	6881068	Open site	Valid	Burial : 50, Artefact : -, Shell : -, Potential Archaeological Deposit (PAD) : -		103440
	Contact Mr.Des Williams	**Recorders**	Ms.Mary-Jean Sutton					**Permits**	4097	
04-2-0222	Ukerebagh Island 2 Tweed ACH Shell Midden	GDA	56	553411	6881901	Open site	Valid	Shell : -		
	Contact	**Recorders**	Mr.Ian Fox					**Permits**		
04-2-0204	Banora PS Tweed ACH Shell Midden	GDA	56	553352	6878025	Open site	Valid	Shell : -		

Report generated by AHIMS Web Service on 19/12/2017 for Isaac Smith for the following area at Lat, Long From : -28.2143, 153.5484 - Lat, Long To : -28.1846, 153.5956 with a Buffer of 1000 meters. Additional Info : REF Information. Number of Aboriginal sites and Aboriginal objects found is 33

Office of Environment & Heritage

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Backpassing REF

Client Service ID : 319410

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0210	Ukerebagh Nature Reserve Tweed ACH Marked Tree	GDA	56	554556	6880981	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0220	Shallow Bay Tweed ACH Shell Midden	GDA	56	554493	6879162	Open site	Valid	Shell : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0229	Ukerebagh Island 4 Tweed ACH Rock Wall	GDA	56	554267	6881334	Open site	Valid	Aboriginal Ceremony and Dreaming : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0230	Boyd Street Tweed ACH Shell Midden	GDA	56	553039	6882752	Open site	Valid	Shell : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0231	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0232	Wommin Lake Tweed ACH Shell Midden	GDA	56	555478	6878077	Open site	Valid	Shell : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0241	Kerosene Inlet 2 Tweed ACH Gathering and Resource	GDA	56	554442	6882567	Open site	Valid	Aboriginal Resource and Gathering : -		
	Contact	Recorders	Mr.Ian Fox					Permits		
04-2-0243	Duffy Street Tweed ACH Stone Grinding Dish Original Locus	GDA	56	553854	6880967	Open site	Valid	Artefact : 0		
	Contact	Recorders	Mr.Ian Fox					Permits		

Report generated by AHIMS Web Service on 19/12/2017 for Isaac Smith for the following area at Lat, Long From : -28.2143, 153.5484 - Lat, Long To : -28.1846, 153.5956 with a Buffer of 1000 meters. Additional Info : REF Information. Number of Aboriginal sites and Aboriginal objects found is 33

Appendix I
Map of Cook Island Aquatic Reserve

Cook Island Aquatic Reserve

Marker	Latitude (S)	Longitude (E)
1	28°11'32.336"	153°34'39.872"
2	28°11'52.114"	153°34'59.282"
3	28°11'54.419"	153°34'46.449"
4	28°11'51.698"	153°34'29.560"
5	28°11'42.806"	153°34'26.280"

153°34'E 153°34.5'E 153°35'E

28°11.5'S 28°12'S

Cook Island Aquatic Reserve

Cook Island Nature Reserve

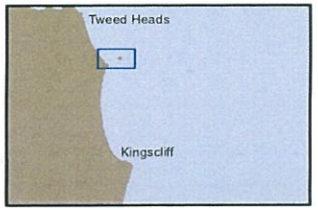
Fingal Head

This map is not to be used for navigational purposes
NSW DPI 2016
Coordinates are shown in WGS84

Aquatic Reserve
No fishing, spearfishing or collecting
Nature Reserve

Public mooring (conditions apply)
Commercial priority mooring (conditions apply)
Marker buoy

0 250 500
metres



Appendix J
Tweed Byron LALC Aboriginal Cultural Heritage Unit inspection report

INSPECTION REPORT

PO Box 6967, Tweed Heads South NSW 2486 21/25 Ourimbah Rd, Tweed Heads NSW 2485 Ph: 0755 361763 Em: culturalheritage@tblalc.com Web: www.

LOCATION ADDRESS: Fingal Heads Beaches

PROJECT: Proposed Beach Nourishment Project - Tweed Heads

CLIENT: The NSW Department of Industry
Crown lands
1243 Bruxner Highway Wollongbar NSW 2478
Em: Isaac.smith@crownland.nsw.gov.au

REPORT PREPARED BY:
Cultural Sites Officer - Warren Phillips and Conservation Planning Officer – Maurice Gannon
Tweed Byron Local Aboriginal Land Council
Em: chsites@tblalc.com

REFERENCE ID:

INSPECTION DATE: Mon 22nd Jan 2018

ATTENTION: Isaac Smith

Thank you for contacting the Tweed Byron Local Aboriginal Land Council (TBLALC) Cultural Heritage Unit (CHU) to request a cultural site inspection. The purpose of the inspection is to assess the impacts of The NSW Department of Industry's proposed beach nourishment project to cultural heritage in the waters off Fingal Head and to the land, particularly the beaches, to the north and south of the headland.

As you are aware the level of consultation required is set out in detail in section C of the Tweed Shire Councils (TSC) draft Aboriginal Cultural Heritage Management Plan (ACHMP). The appropriate point of reference for consultation of the Aboriginal community for the Bundjalung people in regard to this site is the TBLALC (ref ACHMP pg.60).

Participants for the onsite inspection were Office of Environment & Heritage Coastal Adviser Marc Daley and Graduate Engineer Isaac Smith, TBLALC Conservation and Planning Officer Maurice Gannon and Sites Officer Warren Phillips.

SITE INSPECTION OUTCOMES:

On-site discussions highlighted concerns regarding the accumulation of sand at the Tweed River entrance, the requirement for maintenance of a navigable waterway and the related concerns regarding maritime and public safety within that area. It was explained that the relocation of the accumulated sand by dredging from the area around the river mouth and offshore dumping to the south of Fingal Head at Fingal main beach and to the north of Fingal Head at Fingal 'back beach' is necessary to address the navigation and safety concerns. The specific locations for the dumping have been precisely surveyed for optimal deposition on the beaches given known currents, longshore drift, 'sand waves' etc. This type of beach nourishment has been undertaken by the NSW Government for many years.

Reference to the TSC ACHMP mapping identified two cultural sites within waters off Fingal Head; specifically, Cook Island and Fido Reef. There are also a number of registered AHIMS sites on or near the Fingal beaches. Discussions by OEH Coastal Adviser Marc Daley and Graduate Engineer Isaac Smith, indicated the volume of sand to be relocated and the known dynamics of beach sand erosion, deposition and drift would not result in obstruction of the natural flow or tides and would not impact Aboriginal cultural heritage on land or offshore.

RECOMMENDATIONS:

TBLALC recommends that a process of due diligence be followed as outlined in the OEH *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW*. (A copy of the Code is available on the OEH website). This process concludes that all ground disturbance activity should "proceed with caution" and a "stop work procedure" should be in place if any inadvertent discovery of cultural heritage objects is made.

Note that this Inspection Report can form part of the documentation for proceeding in accordance with the OEH Due Diligence Code.

TBLALC appreciates having been consulted and does not require a comprehensive cultural heritage assessment in regard to the proposed program prior to the commencement of the work.

Please contact the TBLALC Cultural Heritage Unit (CHU) if we can be of further assistance.

Appendix K
Backpass Deposition Areas Sediment Particle Size Distribution report

Hydrosphere Consulting

Tweed River Entrance Sand Bypassing Project

Backpass Deposition Areas Sediment Particle Size Distribution

May 2018

Disclaimer:

This report has been prepared on behalf of and for the exclusive use of the DI-Lands & Water, and is subject to and issued in accordance with the agreement between DI-Lands & Water and Hydrosphere Consulting. Hydrosphere Consulting accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

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Cover photo: Looking southward from sample point BP07 offshore from Fingal Beach

Prepared on behalf of DI-Lands & Water by Hydrosphere Consulting.

Suite 6, 26-54 River Street
PO Box 7059, BALLINA NSW 2478
www.hydrosphere.com.au

PROJECT 18-025 – TRESBP BACKPASS SEDIMENT INVESTIGATION

REV	DESCRIPTION	AUTHOR	REVIEW	APPROVAL	DATE
A	Client Draft	M. Howland	U. Makings	M. Howland	20 March 2018
0	Final	M. Howland	-	M. Howland	2 May 2018

CONTENTS

FIGURES

PLATES

APPENDICIES

1. BACKGROUND

The Tweed River Entrance Sand Bypassing Project is proposing to utilise sites offshore from Fingal Beach and Dreamtime Beach for the potential deposition of material gained from future dredging of the Tweed River entrance bar.

The target deposition areas are defined by four polygons of approximately 25ha each spanning a bed elevation range from -3m to -13m AHD. Three of the deposition areas are located offshore of Fingal Beach, between approximately 1.2 and 2.7km south of the pumping Jetty and off Dreamtime Beach, between approximately 150 and 800m south of Fingal Head.

The aim of this report is to determine the grain size compatibility between the Entrance and the two proposed backpass deposition areas.

2. METHODOLOGY

Sediment sampling was undertaken on 1 March 2018. Fifteen sediment samples were collected by benthic sampler from within the proposed deposition areas. Sampling was undertaken during low swell conditions, however significant swell activity (up to H_s 3.6m and H_{max} 6.3m) had occurred in the previous fortnight as shown by Figure 1.

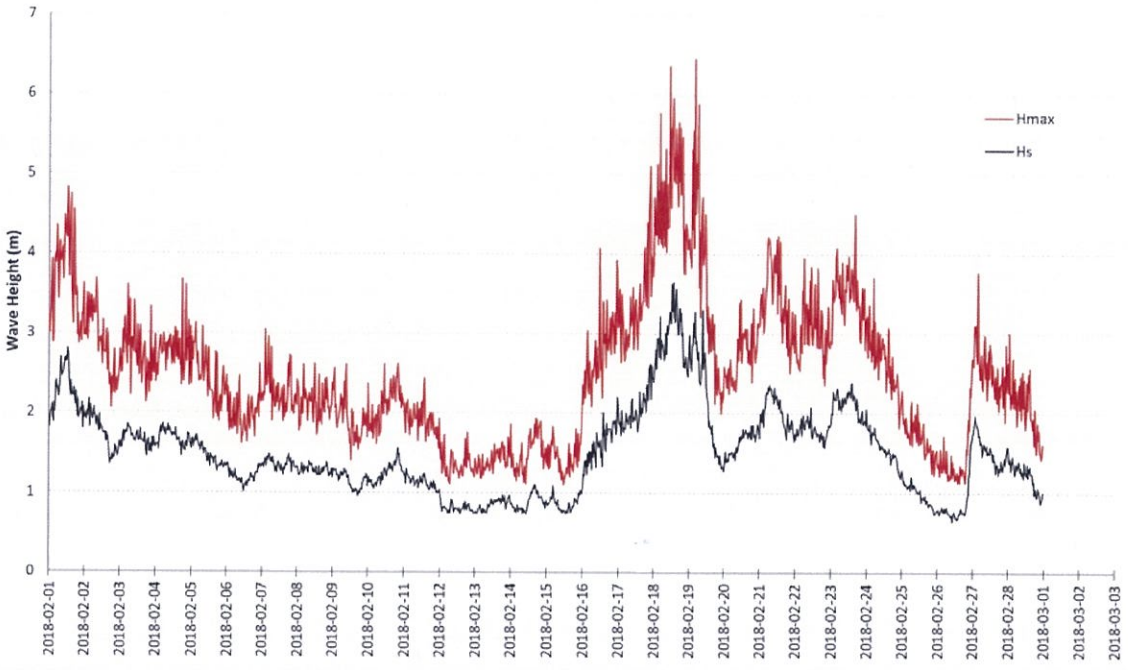
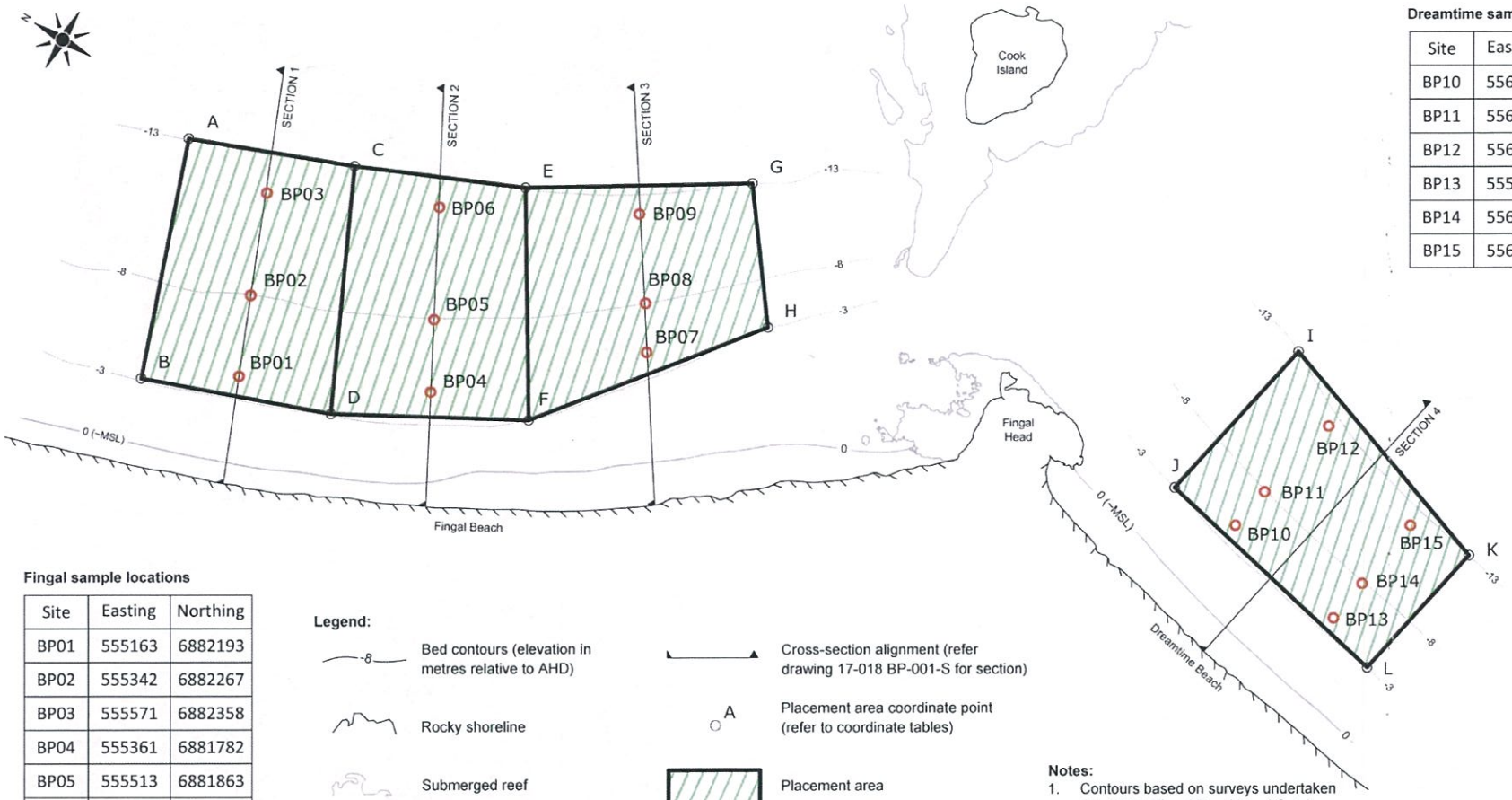


Figure 1. Swell conditions prior to sampling

Sampling locations (Figure 2) were pre-determined in order to best represent the longitudinal and vertical extent of the proposed backpass deposition areas, with nine samples taken offshore from Fingal Beach (3 sections x 3 depths) and six from Dreamtime Beach (2 sections x 3 depths). The target depths were -4, -8 and -12m AHD in each case.



Dreamtime sample locations

Site	Easting	Northing
BP10	556058	6879974
BP11	556162	6879954
BP12	556373	6879902
BP13	555986	6879661
BP14	556092	6879644
BP15	556269	6879615

Fingal sample locations

Site	Easting	Northing
BP01	555163	6882193
BP02	555342	6882267
BP03	555571	6882358
BP04	555361	6881782
BP05	555513	6881863
BP06	555750	6881988
BP07	555702	6881389
BP08	555801	6881450
BP09	555976	6881571

Legend:

-8 Bed contours (elevation in metres relative to AHD)

Rocky shoreline

Submerged reef

Vegetation boundary/beach scarp (July 2017)

Wreck

Cross-section alignment (refer drawing 17-018 BP-001-S for section)

A Placement area coordinate point (refer to coordinate tables)

Placement area

BP Sediment sample sites

0 250 500
Metres

Notes:

1. Contours based on surveys undertaken July 2017 (Fingal Beach) and October 2017 (Dreamtime Beach) by Michel Group Services.
2. Drawing produced by Hydrosphere Consulting 30 March 2018
3. Contour elevations are in metres relative to Australian Height Datum (AHD).
4. All coordinates given relative to Map Grid of Australia Zone 56 (MGA-56)

Figure 2. Deposition areas and sample locations

The boundaries of the proposed deposition boxes and waypoints for sample locations were pre-loaded onto a RTK GPS. Bed elevations were confirmed at each sample location utilising a calibrated survey grade single beam depth sounder linked to the GPS unit, thereby allowing elevation correction for tidal state. Once the survey vessel was approximately in the correct position, the benthic sampler was deployed and the actual sample position plotted. Once retrieved, the sample was transferred to a temporary container for inspection prior to transfer to plastic zip lock bags for later submission to the laboratory.

Particle size distribution analysis was undertaken by Southern Cross University's Environmental Analysis Laboratory, by a combination of wet and dry sieving through 75, 150, 212, 250, 300, 425, 600, 1,000 and 2,000 µm meshes. These sizes were selected to provide the best comparison to existing data for the Tweed River entrance sediments. All particle size distribution results are reported by percentage dry weight passing through these sieve sizes.

No additional sampling was undertaken at the Tweed River Entrance for the current study. Instead, data from previous studies (Refer RHDHV 2018) from several different occasions was used to characterise the Entrance sediments.

3. RESULTS

Sediment samples were successfully collected from each of the intended locations. Bed elevations determined during sampling closely matched the expected elevations based on previous hydrographic survey and there was no requirement to alter the pre-determined sample locations.

All samples consisted of Holocene quartzose sands, with relatively low levels of fine, broken shell material. The apparent grain size of the material, as observed at the time of sampling, was variable but displayed generally consistent trends as described in the following sections.

The consistency of the sediments, from the NW, NE, SW and SE extremes of the sampling area is shown below in Plate 1.

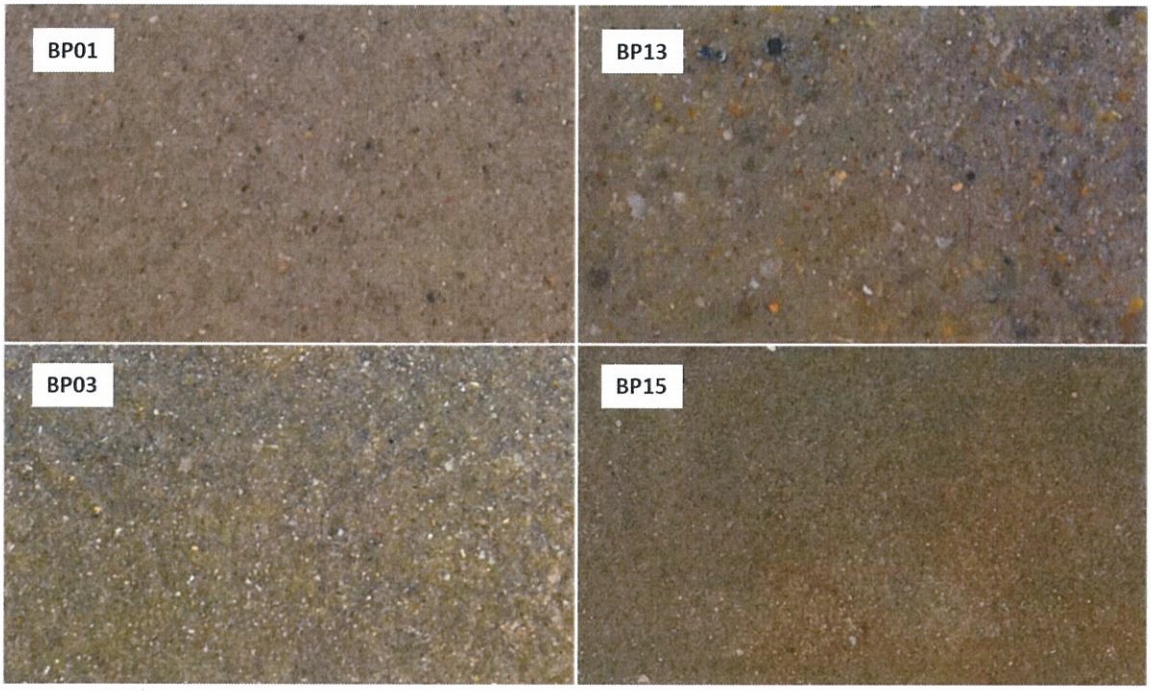


Plate 1. Sand samples from BP01, BP03, BP13 and BP15

3.1 Fingal Beach

Sediments offshore from Fingal beach (BP01-BP09) were composed virtually entirely (99.9%) of sand-sized fractions (75-2000µm), with a negligible amount of material greater than 2mm diameter which was observed to be primarily fine shell material. The inshore (-4m AHD) samples (BP01, BP04 & BP07) consistently displayed coarser grain size, whilst the offshore (-12m AHD) sites (BP03, BP06 and BP09) consistently held finer sediments (Figure 3). There was very little longitudinal variation over the 1km stretch of coastline sampled.

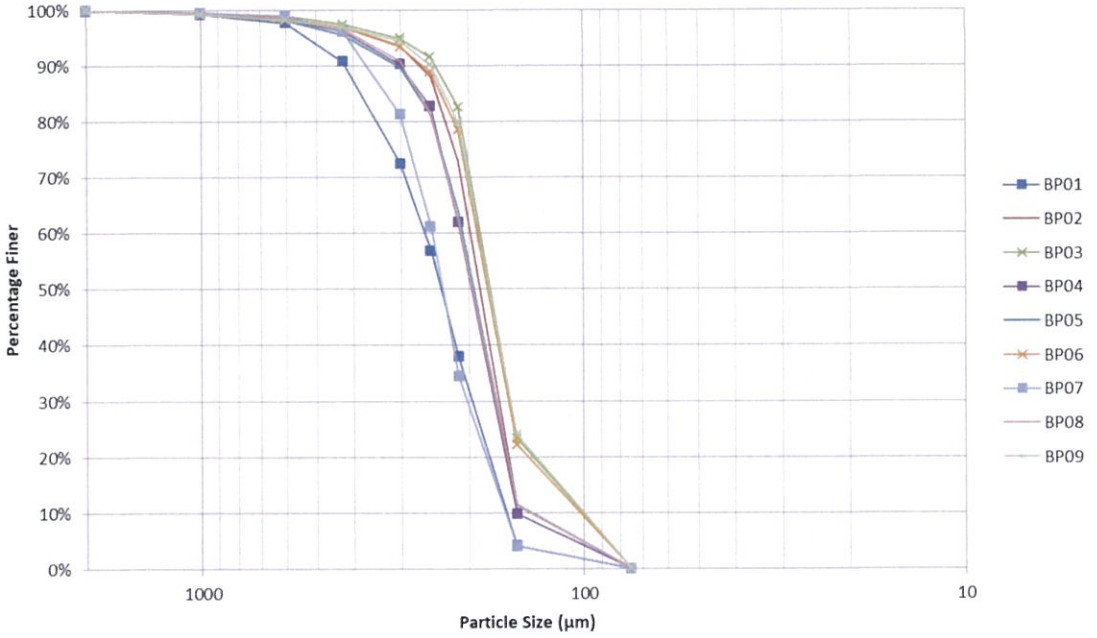


Figure 3. Particle size distribution of Fingal samples (BP01-BP09)

3.2 Dreamtime Beach

The deeper sites off Dreamtime beach had very similar sediments to those at the same depth at Fingal, however the inshore (-4m AHD) samples, particularly BP13, were visibly coarser than all other samples (Figure 4). The depth of samples off Dreamtime Beach seemed to be much more influential on the grain size distribution than depth off Fingal Beach.

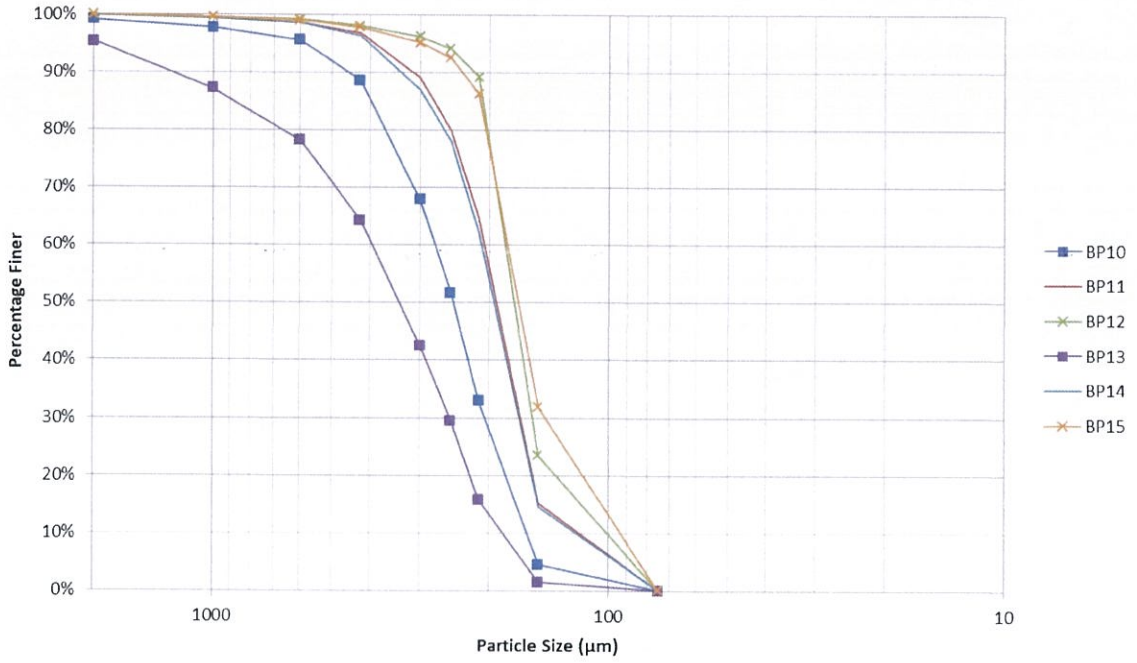


Figure 4. Particle size distribution of Dreamtime samples (BP10-BP15)

3.3 Comparison to Tweed River entrance samples

The particle size distribution of the historic Entrance data (refer RHDHV 2018) was used to calculate the 95% confidence interval (Figure 5) which was used for comparison with the samples from the Fingal and Dreamtime backpass areas collected during this study.

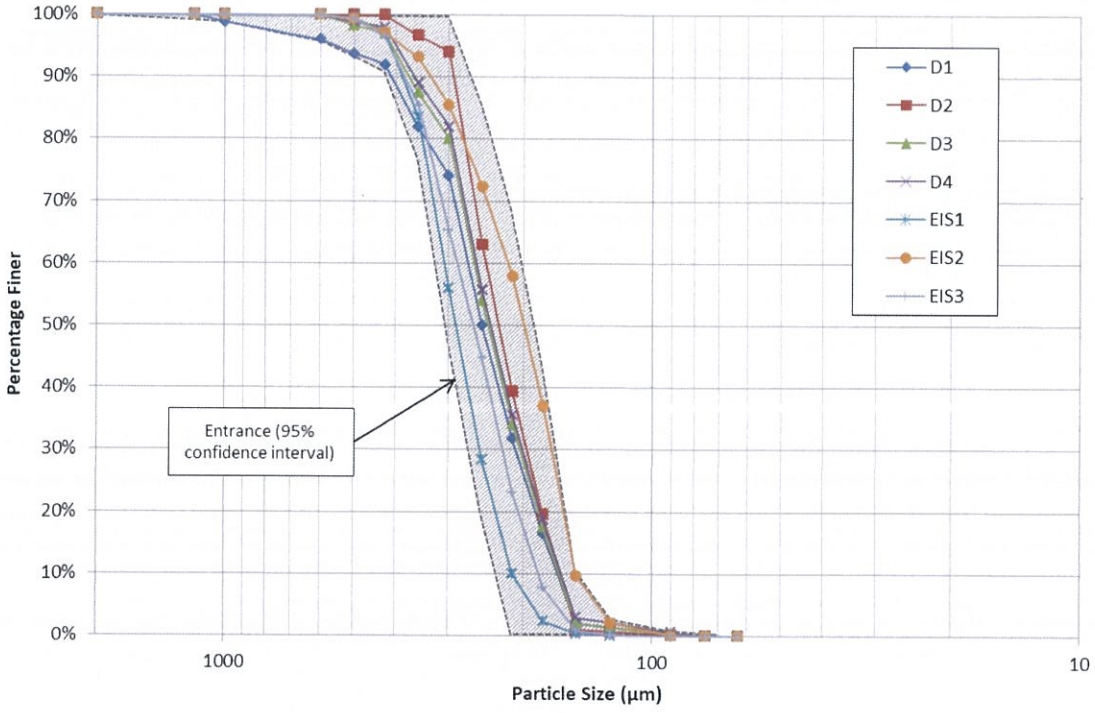


Figure 5. Particle size distribution and 95% confidence interval for historical Entrance samples

3.3.1 Fingal

The inshore Fingal sediments closely matched the grain size distribution of the Entrance bar sediments (Figure 6). Inshore sand from Fingal Beach is most likely to eventually end up on the Entrance bar through longshore drift and the similarity between these sites was consistent with expectations.

A common phenomenon at all sites was the gradual increase in finer sands with depth and it can be seen that the deeper sections (-8m and -12m AHD) of the Fingal backpass areas have a marginally finer grain size distribution compared to the Entrance bar.

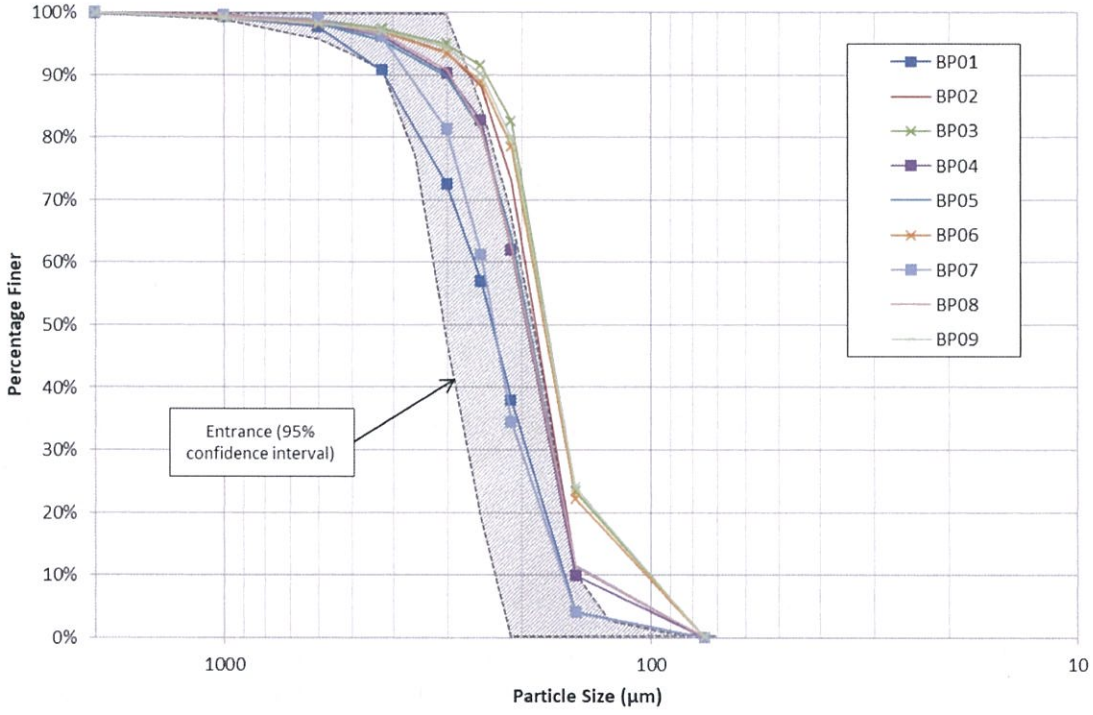


Figure 6. Particle size distribution for Fingal samples in comparison to historical Entrance particle size distribution.

3.3.2 Dreamtime

Sample BP13 (southern inshore) had significantly higher proportions of coarser material and was relatively unique compared to all other sediments considered in this study (Figure 7). This fact was observable whilst undertaking field work and a duplicate sample at BP13 was obtained to verify the field consistency at that location. As no obvious difference was apparent, only the original sample was submitted for analysis. There were no observable factors identified in the field to explain the coarser sediment, however it was noted that the bed slope was steeper in this location than the corresponding depth at Fingal. Although some fine shell was present within this sample, and many other samples, its low density and relatively low abundance indicated that this is not a major factor in explaining these differences.

As with the Fingal samples, sand grain size decreased with distance offshore, with the deepest (-12m AHD) samples (BP12 and BP15) being similar to the same depth at Fingal and lying marginally outside of the 95% confidence limits for the previously sampled Entrance sediments.

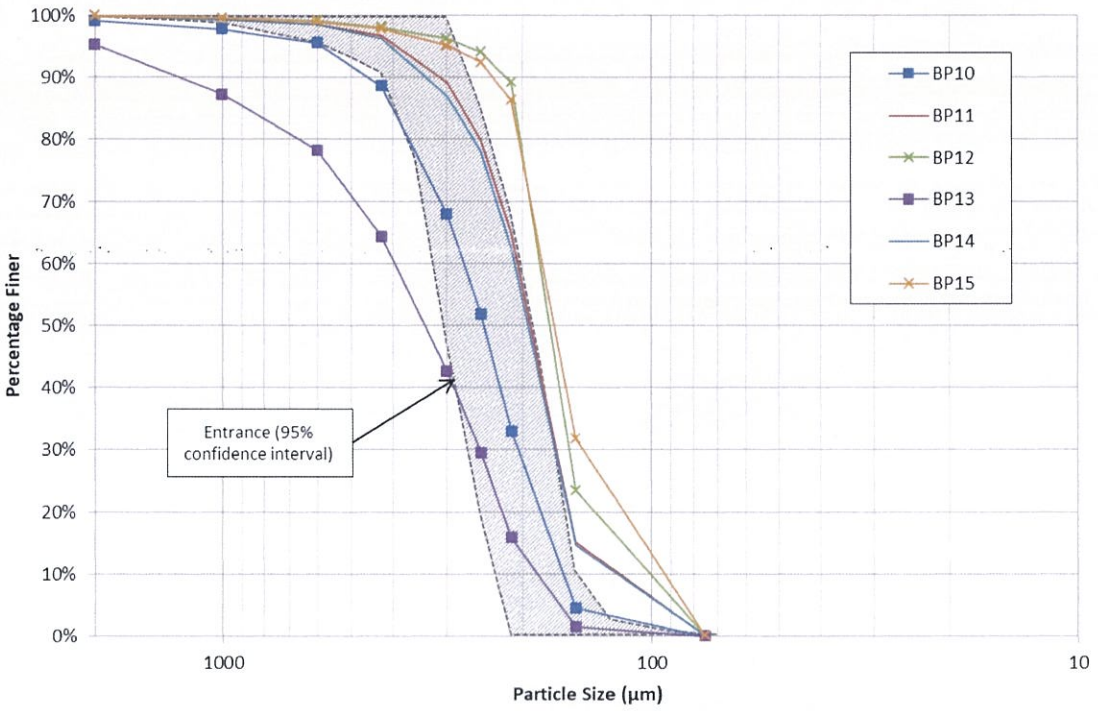


Figure 7. Particle size distribution for Dreamtime samples in comparison to historical Entrance particle size distribution.

4. SUMMARY AND CONCLUSIONS

Sediment samples taken offshore of both Fingal and Dreamtime beaches consistently showed that the particle size distribution became finer with depth. Sediments taken offshore of Fingal beach, at similar depths to the Entrance bar (i.e. -4 to -8m AHD), were shown to have very similar grain size characteristics to the Entrance.

The grain size distribution offshore of Dreamtime Beach occupied a broader range with the best match to the Entrance bar sediments occurring once again with the shallower (-4 and -8m AHD) samples with the exception of the most southerly inshore sample at Dreamtime Beach which was noticeably coarser than all other samples.

5. REFERENCES

RHDHV (20118) Snapper Rock East Sand Tracing Study Interim Report. 8 January 2018.

Appendix 1. Laboratory grain size analysis results

PARTICLE SIZE ANALYSIS (sieving technique) (Page 1 of 1)

15 samples supplied by HydroSphere Consulting Pty Ltd on 2nd March, 2018. Lab Job No. G7977
Analysis requested by Mick Howland. **Your Reference: 15 samples for particle size distribution**
PO Box 7059 BALLINA NSW 2478

SAMPLE ID	Lab Code	> 2 mm	1-2 mm	600 μm-1 mm	425-600 μm	300-425 μm	250-300 μm	212-250 μm	150-212 μm	75-150 μm	<75 μm
BP01	G7977/1	0.15%	0.70%	1.49%	6.94%	18.26%	15.60%	18.93%	33.82%	4.10%	0.01%
BP02	G7977/2	0.17%	0.27%	1.13%	1.46%	3.35%	5.51%	15.07%	61.59%	11.43%	0.01%
BP03	G7977/3	0.05%	0.53%	0.59%	1.43%	2.46%	3.43%	8.90%	59.26%	23.30%	0.05%
BP04	G7977/4	0.00%	0.62%	1.10%	2.14%	5.91%	7.57%	20.76%	52.02%	9.85%	0.02%
BP05	G7977/5	0.05%	0.73%	1.10%	2.54%	5.84%	8.50%	17.26%	52.46%	11.49%	0.02%
BP06	G7977/6	0.06%	0.66%	0.85%	1.44%	3.59%	4.54%	10.33%	56.32%	22.16%	0.05%
BP07	G7977/7	0.00%	0.50%	0.57%	2.85%	14.82%	20.08%	26.77%	30.39%	4.03%	0.00%
BP08	G7977/8	0.00%	0.60%	1.07%	1.76%	5.71%	9.60%	19.05%	50.84%	11.35%	0.01%
BP09	G7977/9	0.10%	0.77%	0.98%	1.13%	2.61%	4.35%	10.24%	55.80%	23.94%	0.07%
BP10	G7977/10	0.87%	1.38%	2.20%	6.96%	20.73%	16.13%	18.77%	28.44%	4.51%	0.00%
BP11	G7977/11	0.00%	0.47%	0.95%	1.81%	7.67%	9.26%	15.10%	49.55%	15.16%	0.04%
BP12	G7977/12	0.00%	0.41%	0.41%	1.15%	1.82%	2.12%	4.86%	65.79%	23.38%	0.06%
BP13	G7977/13	4.71%	8.07%	9.04%	13.92%	21.72%	13.04%	13.71%	14.36%	1.44%	0.00%
BP14	G7977/14	0.14%	0.54%	0.78%	2.24%	9.29%	9.07%	15.69%	47.62%	14.62%	0.01%
BP15	G7977/15	0.00%	0.46%	0.52%	1.20%	2.66%	2.68%	6.14%	54.49%	31.75%	0.10%

Note:
1: The Dry and Wet Sieving Analysis method was used for this grain size determination (Method of: Lewis and McConchie, 1994. Analytical Sedimentology. Chapman and Hall, USA.)

checked: .....
Graham Lancaster
Laboratory Manager

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal